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CHARLES P. BOYLE

JUNE 1973

GSFC — GODDARD SPACE FLIGHT CENTER
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Charles P. Boyle

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GODDARD SPACE FLIGHT CENTER
Greenbelt, Maryland

FOREWORD

Side I

"Never forget, Son, that your father sold office supplies to the company that made the box that carried the rocks back from the moon."

Side II

When I heard the learn'd astronomer,

When the proofs, the figures, were ranged in columns
before me,

When I was shown the charts and diagrams, to add,
divide, and measure them,

When I sitting heard the astronomer where he lectured
with much applause in the lecture-room,

How soon unaccountable I became tired and sick,

Till rising and gliding out I wander'd off by myself,

In the mystical moist night-air, and from time to time,

Look'd up in perfect silence at the stars.

Walt Whitman
1819-1892

PREFACE

Actions in any area will inevitably have second-order consequences. These consequences are frequently of greater importance than the original actions. This is especially true of technical innovations. They recurringly produce second-order social, economic, and political changes that were neither intended nor anticipated.

One of the better known examples is the introduction of the automobile as a means of transportation. "It has changed our leisure life and (allegedly) our sexual mores and practices; spawned suburban living; changed our patterns of home ownership and retail distribution; introduced the use of road building as a source of patronage; decimated the railroads; and introduced a new holiday pastime of counting death tolls. None of these events, insofar as we know, was intended, few were anticipated, and not all are desired."[1]

NASA and others are actively considering the wide range of effects, favorable and unfavorable, which may result from the space program. NASA has commissioned studies in this area and others have been done independently. Interest dates from almost the start of the space program. For example, the Brookings report of 1961 provides about two hundred pages of potential implications.[2]

The exploration of space, a massive technical effort by many nations, will surely have many second-order consequences. The beneficial effects are more easily anticipated than the undesired because in most instances they will be planned for. In some areas, effects are already being reported . . . favorable, unfavorable and inconsequential. In others prediction is active but is unavoidably speculation. This document reports on effects that have occurred, that are probable, and that seem possible.

NOTE:

A new activity as vast and diverse as space exploration has second-order consequences on a global scale. The effects occur at random in the world community. They are examined at random in this publication. The extensive Index should offset the random Table of Contents.

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EFFECTS OF SPACE RESEARCH ON SOCIETY

In today's pell-mell society, we encounter and absorb the new with little reflection on its significance. This may explain why the effects of space research are so little noticed although they are all around us. But two other factors have been at work. One is the deluge of publicity accompanying manned space flights. The other is the national controversy over the lunar landing program versus other priorities. Thus, due to being focused on these spectacular achievements and debates, the public's ability to see the many and varied effects of the entire space program has been diminished.

"Take Me To Your Leader"

Some effects have been behavioral. For example, the international sense of humor has broadened; space-oriented stories and jokes abound, and many nations have their version of the cartoon caption "Take Me To Your Leader." The public vocabulary itself is influenced as space terminology leaves the laboratory and enters general usage. The precedent of manned space travel helps explain the public's open-mindedness about the recurringly reported "sightings" of Unidentified Flying Objects. Entertainment has been affected with a proliferation of space-related movies and TV dramas and series.

The Flat Earth Society

Age-old concepts have been impacted, and expressions of popular wisdom such as "What goes up must come down" are no longer heard in the land. The terms "Impossible!" and "It can't be done!" are less used nowadays, because recent experience still smarts. Even Britain's Flat Earth Society accepts the fact of man in orbit (around the rim, of course). There is also the phenomenon of a public schizophrenia toward space, to wit: funding support has been declining for years while manufacturers increasingly use admiration for the space program as the basis for campaigns advertising their products. And we are apparently proceeding to the astounding situation in which some of the people of the future may ask, "Remember when men used to go to the moon?"*

*Appendix A

What Kinds of Effects?

Some space-related influences have already revised our style and our standard of living. Others have affected our ways of thinking and enlarged the scope of our planning. Still other influences are futuristic: they are providing alternatives that never before existed for the solution of difficult societal problems. The futuristic effects will be felt increasingly with time, and they will be considered extensively in this publication.

In their nature, the effects of space research are believed to be humanitarian, technological, political, legal, educational, ecological, managerial, motivational, governmental, social, medical, philosophical, conservational, economic, and spiritual.

The factors which fuel these beliefs deserve to be examined.

Source and Destiny

Inquiring into the origin of our universe is a major aspect of the space program; it thus contributes to man's age-old search for the Creator. Man has always puzzled over who and what he is. His concept of himself and his universe was never the same after Galileo's telescope came into use. The achievement of manned space flight marks a comparable point of change in man's thinking. Man, who once thought of himself as the eminent created being, located at the center of the heavens, now tries to communicate with creatures of equivalent or superior mentality. The spacecraft Pioneer 10, the first whose flight path was chosen to fling it out of our solar system, carried a plaque with a message to these possible unknown beings in other star systems.* Newspaper coverage of this plaque produced comments to NASA. Some objected that Earthmen should not let "them" know we exist or where we live. Others approved, in the spirit of exploration. Still others rejoiced, seeing the plaque as verification of St. John, 10th Chapter, 16th Verse: "Other sheep I have which are not of this fold."

The reality of the universe in which man lives is now plainly evident to him for he has been out *into* it. Now, more than ever, it creates great wonder in him about himself and his destiny. Few who heard Astronaut Borman reading from Genesis while rounding the moon on Christmas Day, 1968, can ever forget the emotions sparked by those words. For many it was a moving spiritual experience. A few were angered including Mrs.

*Appendix B

Madalyn Murray O'Hair who promptly filed suit against the NASA Administrator, seeking (unsuccessfully) to ban prayer from space as she had from schools.

From obscure origins man has evolved over a billion years as a prisoner of this planet. Now, when he is capable of investigating his origin and speculating about his future, he may have no future. Given our human nature and our weapons, permanent extinction will remain a distinct possibility until mankind is dispersed in space. After that the human race might well be invulnerable. From the moon colonies and the orbiting stations may come the handful who would repopulate the Earth after the radioactivity has cooled off. Only by such dispersion can there be assurance that man would evolve toward a different destiny.

Man's Outlook

Alexander Pope said long ago: "The proper study of mankind is man." Such study could not be fruitful without also studying man's environment, for his environment influences his behavior. We have been out into the universe, the environment of our planet. The view should humble us, but the deed should make us proud. We are gaining something philosophically valuable: perspective. We see our significance in the cosmos clearly now, and yet we venture still. This striving and seeking makes us more human, less animal. All animals instinctively feed and reproduce. Only man spends most of his time in efforts beyond those necessary for survival. Sculpture and painting and attempts to explain his world are basically superfluous activities. But how attractive would life be without such activities? And history shows us that what is superfluous today may benefit society tomorrow. Years ago, studying electrical phenomena was considered superfluous. Yet all social planners of today assume in their proposals the ready availability of electric power.

Motivation and Entity

The space effort provides examples, techniques, methods, and inspirations to help solve some of the nation's great problems. This is especially true of problems which are sociotechnical in origin. With these, we can properly be intolerant of explanations for non-performance which plead technological inability. It is other factors, principally time, expense, and human behavior, which become controlling influences. The Apollo program has shown us that the needed technology exists

or can be produced. This does not mean that the management concept of Apollo is applicable to such problems, however. As NASA Administrator Dr. James C. Fletcher puts it ". . . essentially we were dealing with machines, not people." And Astronaut Frank Borman emphasizes, "I don't think that I would care to live in a country that solved its social problems in the same way we solved the Apollo problems." Dr. Fletcher calls for a new breed of public leader, one who can combine science and technology with administrative ability, simultaneously considering science and human needs.

Space research has also provided us with additional motivation to work together and to help one another. Why? Because the Earth is now seen as one entity, not numerous political subdivisions. Because the view from the universe has truly clarified our relationship to our fellow man . . . the other passengers on spaceship Earth. Ignoring certain needs of the humans of other nations is now seen to be equivalent to telling a shipmate, "Your end of the boat is sinking."

Pulitzer Prize author Archibald MacLeish said it best: "To see the earth as it truly is, small and blue and beautiful in that eternal silence where it floats, is to see ourselves as riders on the earth together, brothers on that bright loveliness in the eternal cold – brothers who know now that they are truly brothers."*

The Great Boon

Awareness of Earth as an entity has produced what many regard as the greatest space research effect of all. It is well expressed by Dr. Gordon Goles, a volcanologist from the University of Oregon.

"Ecologists and biologists and geochemists have been screaming their bloody heads off for decades about what we're doing to our environment and nobody gave a damn. Nobody even listened.

"Now, all of a sudden, in the same year when there is televised to millions of people a view of our planet from outside – from far enough outside that you can see, and you can feel it in the pit of your stomach, that here is one entity, one closed system on which we all must live – in that same year, we get this sudden concern.

"I do not think these two things have occurred in the same time span by accident.

*Appendix C

"In fact, I would like to suggest that in future years . . . historians will say that far and away the most useful result of the moon program was a change in the psychology of many millions of people who realized for the first time, in a way that could not be denied, that they were all on one small planet, a planet that's unique in the solar system, and that they depended on it for their lives."[3]

The Decimation of Society

The greatest impact space exploration could have on society would be the extinction of society. Some people feared that this would occur when lunar material was brought here. The contamination of Earth by entirely foreign organisms which could be disastrous to crop, human or animal life must be considered a distinct possibility in any round trip planetary probes, manned or unmanned. The safeguards and quarantine arrangements for the initial landings on the arid moon proved to be unnecessary. With other planets, e.g., Mars, the risk will be far greater. Because no quarantine is absolute, it may be necessary to include a lengthy test period aboard an Earth orbiting space station, wisely avoiding direct return to this planet.

The Closed Society

Social change also includes the laudable goal of trying to open up the closed societies of the world. America's space activities performed openly on the world stage, in dramatic comparison to Soviet secrecy, have unquestionably helped.

Later in this century totalitarian regimes may find it difficult to censor news of the outside world because the powerful direct broadcast satellites of other countries will beam down on neighboring territory.* We must realize however, that communications methods such as direct broadcast TV also have a detrimental potential, that of propaganda and opinion control. Those who remember the effectiveness with which Nazi Propganda Minister Goebbels utilized radio alone can truly appreciate the potential.

Social change may be promoted also by what we are learning. Astronomer John O'Keefe says: "One result of space research is the realization that the universe seems to have been

*Appendix D

created rather suddenly about ten billion years ago. This is a very awkward point for the apostles of dialectical materialism, the philosophy that goes with Communism. They have always said that the universe must be infinite and eternal; they have always fought against the idea that it was created at some particular time."

Competition and War

Peoples of all nations are concerned when brave men are in danger. This has led to offers of assistance in astronaut emergencies. These offers have produced agreements. The agreements make cooperation necessary. Such cooperation can lead to collaboration, and real collaboration seems to have started at last. Recently in Star City, near Moscow, a NASA team reached agreement with a Russian team about the design of compatible equipment that would provide each country the ability to rendezvous, dock with, and enter the other's spacecraft. The motivation is mutual rescue capability. There is also an agreement to exchange lunar samples. And a Joint Editorial Board has already met to publish a review of space biology and medicine. Who knows where this collaboration may lead?

There are some spokesmen who believe that even were there no *cooperation* in space, society would benefit from *competition* in space. They believe that competition has already served as a substitute for war. It is seen as a public concentration of national resources, imagination, technological advancement and energy against an opponent in "an alternative to destructive war."[4] More surely, however, humanity will benefit from the next phase: cooperative international space efforts.

Common Cause

NASA has already cooperated with some 74 countries in activities which have included atmosphere probes, information exchange, communication satellities, aid in developing their own launchers, and the launching of foreign experiments on U.S. spacecraft.

The new phase of space cooperation is intended to involve foreign countries in the building of manned-flight space vehicles. It may include the most challenging project undertaken in space to date – the development of a reusable space shuttle (Fig. 1). This will transport crews and cargo from earth to orbit and later land like an airplane. Costs will be significantly lowered because we will not be throwing away the launch vehicle (Appendix E).

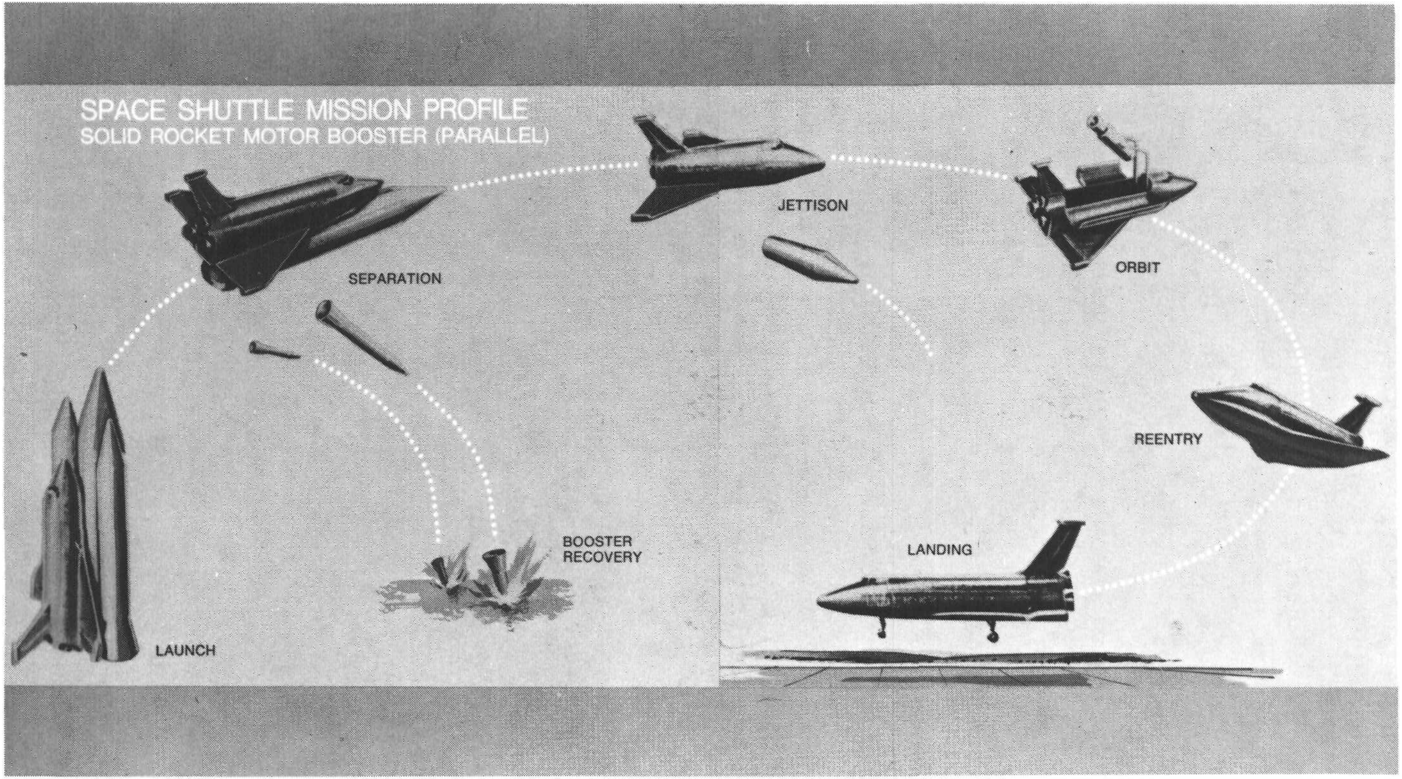


Figure 1. Artist's concept of the space shuttle system being built by the North-American Rockwell Co.

Ten years ago it cost $100,000 per pound to deliver a payload to orbit. Now it costs only one percent of that, about $1000. The shuttle is expected to reduce the price to near $100 per pound. The technology resulting from the development of the shuttle could lead to a global passenger transportation system, according to Najeeb Halaby, recently chairman of Pan American World Airways (Appendix F).

Competing companies have put together international teams to work on this demanding job. One bidder, North American Rockwell (NAR) teamed up with German, British, and French firms. The president of NAR, W. F. Rockwell, Jr., says: "Let me emphasize that these companies are paying their own way. These companies and their countries can see tangible benefits for both their national and business interests."

Curtailment and Trade

It seems strange that as our country is curtailing its space program, other countries are striving mightily to develop theirs. It is possible that they see benefits to a space program which we do not see? Perhaps more is at stake than international cooperation. Consider international trade. How many Americans realize that space exploration is creating a new and rapidly growing export business for the U.S.? Here are a few examples from issues of *Space Business Daily:*[5]

- Japan has cancelled the development of its Q rocket . . . and will seek instead the use of a United States liquid first-stage booster, with interest centered on the THOR DELTA or the ATLAS.
- Telesat, Canada, has signed a contract with Hughes Aircraft for development and fabrication of a $28 million domestic communications satellite system for Canada.
- North American Rockwell has agreed with Wanner Isofi Isolation of France to form a new company to produce advanced insulation materials developed for the S-II second stage of the Saturn V. The material is twice as effective as conventional insulation materials.
- The RCA Corporation satellite communications ground station used in Shanghai for televising President Nixon's visit was purchased by the Peoples Republic of China for $2.5 million.
- Bendix Corp.'s Aerospace Systems Division has been selected to design and build an Earth Resources Telemetry Recording System and a Data Processing Station

for Brazil. The station will process magnetic tapes of data received from the U.S. Earth Resources Technology Satellite (ERTS).

A major trade example is the U.S. export that increased 1400% in the first decade of the space age. It comes from the fastest growing U.S. industry, and contributes most to the American balance of trade, i.e., computers. The Christian Science Monitor said recently: "Almost every major computer system in the world is made in America, but without the forcing functions of NASA's requirements, these computers would not be available today. And now the computing industry is an $8 billion-a-year business that pays the highest wages of all U.S. industry."[6] It is estimated that these advances in computer technology will save more money in the next decade for government and industry than the entire Apollo program cost.[7]

Monopoly and Fear

Some American companies are applying to their operations the knowledge emerging from space exploration. This has caused concern among some Europeans about a space "technology gap." Recently Professor Herman Bondi, former Director General of the European Space Research Organization, said: "Much of Europe has a deep fear that the U.S. will use its dearly acquired launching capability to grant its space industry a virtual monopoly in commercially valuable space exploration."[8]

That was a statement from a potential competitor emphasizing the direct commercial value of space. Is space basic to the economic strength of our nation or are we deluding ourselves? Consider these words from a man who spent 18 days in orbit: ". . . we conducted more than 50 experiments, a great number of which are of primary importance to the national economy."[9] The speaker was Cosmonaut Andrian Nikolayev of the recordbreaking SOYUZ 9 flight, proclaiming benefits to the Russian economy.

The nations of Europe and Asia which are striving to develop a space capability recognize clearly that today's science is tomorrow's technology and the day-after-tomorrow's world trade position.*

The Other Peoples' Prize

Space is indeed significant for our economy, for what does the U.S. have to export? We don't have many raw materials, and

*India's reasons are given in Appendix G.

almost anybody can make things cheaper than we do. The answer is that advanced technology is really the only unique product we have to export. Our sole advantage is brainpower and research.

Dr. W. D. McElroy, Director of the National Science Foundation, said recently, "Over most of the past decade, only one category of exports has produced a favorable balance of American trade. That category is high-technology manufactured items. During this time, agriculture, fuels and minerals, and low-technology manufactured items had a negative balance of trade. Here is convincing evidence that science and technology are the basis for our economic success in competition with other nations. In other words, what we have that other people prize most depends, to a large extent, on the results of our research and development."[10]

The influence of high-technology exports is clearly evident from the Dept. of Commerce statement, "The export of a single jumbo jet offsets the importation of 12,000 small cars."[11] And as the U.S. Patent Commissioner, Robert Gottschalk has pointed out, "The U.S. receives over a billion dollars annually for licensing its technology abroad."

Use of the Discovered

There is, however, a problem of delay in getting new knowledge put to use in industry. Michael Faraday produced an electric motor in 1840, but it was not put to use until over forty years later. Even adapting the military jet engine to commercial use took more than ten years. To speed this process, for the benefit of our economy, NASA's Office of Technology Utilization has placed heavy emphasis on three steps – identification of innovations, documenting them, and spreading the word. It uses two systems:

(1) A bank of 900,000 scientific documents, indexed on computer tapes for instant retrieval. It grows by 6,000 documents per month.

(2) A subscription service for distributing knowledge of new technology to industrial clients via Regional Dissemination Centers (RDCs) operated by universities or research institutes and partially funded by NASA.

These systems have helped companies improve production processes, establish priorities for research and development, avoid duplication of research already done elsewhere, improve managerial practices, and create new products.

The Transfer Concept

One means of transmitting this information is the Tech Brief (Fig. 2) that is widely circulated to industry by NASA. One Brief announced a new type of shock absorber originally designed for the astronauts' couches. Industry picked it right up. The concept is now being used in highway crash barriers, effectively cushioning a 50 mph crash to the equivalent of 5 mph (Fig. 3).

There are hundreds of such transfers of technology to industry, but we are interested in concepts, not lists. There is already evidence that the value of transfers is clear to our competitors. For example, this item appeared recently in Newsweek: "The Omron Tateisi Electronics Co. of Japan recently hired ten topflight American engineers and technicians, many of whom once worked for U.S. companies involved in America's space program. The Japanese firm intends to install the Americans in a unique 'industrial think tank' at Mountain View, Calif., and set them to work on consumer applications of space technology. The new techniques and products the Americans develop will, of course, be sent off to Japan for commercial exploitation."[12]

One American company engaged in such efforts is the Industrial Products Division of Hughes Aircraft. It has applied laser technology to the $50-billion-per-year clothing industry and developed a computer-driven laser cutter which reduces response time for orders from six weeks to three weeks (Fig. 4). It provides a fast reaction, small order, small inventory capability for American firms to remain competitive with overseas producers.

The Forcing Function

Space technology has forced numerous basic improvements in production processes in U.S. industry. Most companies, in order to meet NASA requirements for space hardware, had to reach new standards of quality control and reliability. These requirements forced the creation of new materials, manufacturing methods, and testing procedures which will eventually save consumers billions of dollars. Corporations have already adapted many of these improvements for their commercial products and are proudly telling the world about it.

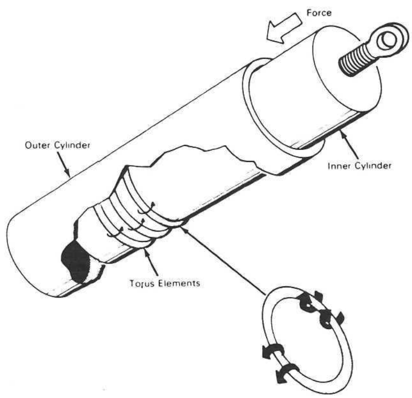
A recent magazine ad showing egg cartons made of a new material proclaimed "On the way to the moon, LTV Aerospace

July 1966 Brief 66-10318

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Torus Elements Used in Effective Shock Absorber



The problem:
To design a high rate energy absorption device that will operate equally well in tension or compression with repeatability.

The solution:
An energy absorbing device that forces torus elements to revolve annularly between two concentric tubes when a load is applied to one of the tubes.

How it's done:
The device consists of two concentric tubes between which a varying number of torus elements can be mounted. The torus elements are loops of ductile material either in the form of rings or a continuous spiral. As illustrated, with a load imposed on one of the tubes, the torus elements are forced to revolve between the tubes, introducing cyclic tension and com-

(continued overleaf)

Figure 2. Sample of the single sheet Tech Briefs published by NASA to publicize technological developments available for utilization by American business and industry.

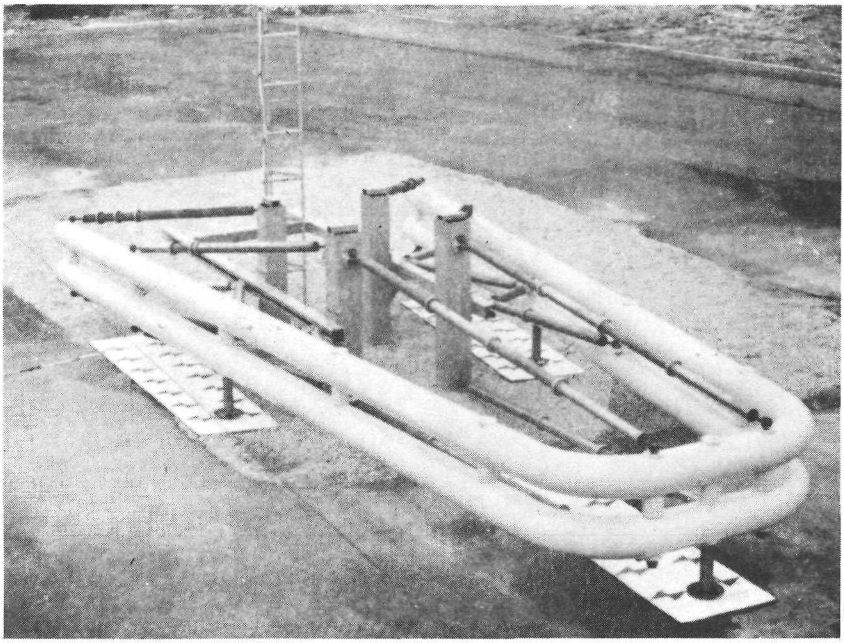


Figure 3. Highway crash barrier utilizing a shock absorption principle originally applied in cushioning astronauts' couches for splashdown impact.

learned a great deal about making life better on earth." Full page ads have appeared, stressing the adaptability of the technological base developed by corporations which performed to NASA standards. (Appendix H.) One ad mentioned a company's work in producing a heart-assist pump. It read in part, "The severe reliability levels called for by flight to an outer planet make you refine and sharpen your technology to extremes, where-upon it suddenly becomes useful here at home within the body of a living man."

Current advertising by Volkswagen clearly shows how the space-prodded development of sensing devices is finding commercial usage: "When man went to the Moon, the success of each mission depended to a great deal on a highly technical computerized system that told the Astronauts the exact condition of their space vehicle. A similar system is now built into every 1972 Volkswagen. Running throughout the car is a network of sensors, each reporting the condition of various parts of the car . . . providing 60 vital service checks."

Space technology has also forced the growth of new industries, or created new companies within existing industries.

Figure 4. Engineers observe the results of cloth cutting performed by a computer-driven laser cutter.

For example, NASA's demands and specifications moved the scale and standards of vacuum technology so far and so fast that vacuum processing techniques quickly became practical in production line operations. Also, NASA's requirements for large amounts of super-cold liquids caused the cryogenics industry to blossom.

Another example is the first significant improvement in pipeline material in 50 years. The United Aircraft Company produced it from knowledge gained in research and development of rocket cases made by winding glass thread onto a mandrel. The new pipe is nearly six times lighter than some in use today, low in cost, and practically indestructible. It was recently used

for an 11-mile pipeline tapping the Great Salt Lake in Utah. The light weight of the pipe makes helicopter installation practical in difficult terrain (Fig. 5).

Power Sans Pollution

Nations desperately needing more electric power can currently obtain it only at the price of increased pollution, whether thermal, gaseous, or particulate. The prospect of space-developed

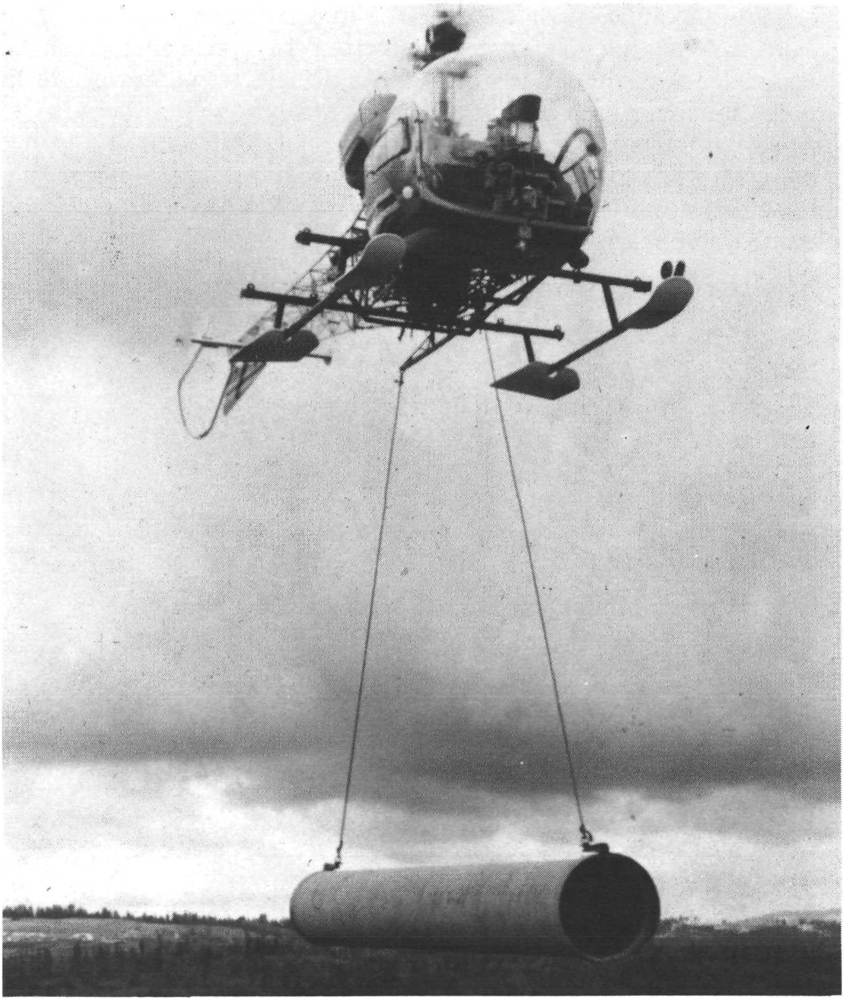


Figure 5. Small helicopters can easily position large sections of the new, light-weight, filament-wound piping in relatively inaccessible sites.

This page is reproduced at the back of the report by a different reproduction method to provide better detail.

power sources gives society a different choice than pollution-versus-brownouts.

One non-polluter is the solar cell, which has long been used on spacecraft to convert sunlight into electricity. Extensive efforts are in process to develop mass-produced solar cells at low cost. Progress is encouraging. Arrays of these cells could augment our power supplies. In fact, if these devices covered 1% of our land area, they could provide the total U.S. electrical power requirement in the year 1990.[13] Some energy specialists envision these in orbit. Solar arrays can now be launched in a rolled-up condition and opened into flat sheets in space. Their electrical energy could be converted into microwave energy, beamed to earth and reconverted into electrical power. A five mile square array at synchronous orbit* would supply ten million kilowatts of power (Fig. 6). Fanciful? Not if the need dictates. The inventors of the log canoe could never have imagined the liner Queen Elizabeth. We are probably at a comparable stage in space transportation.

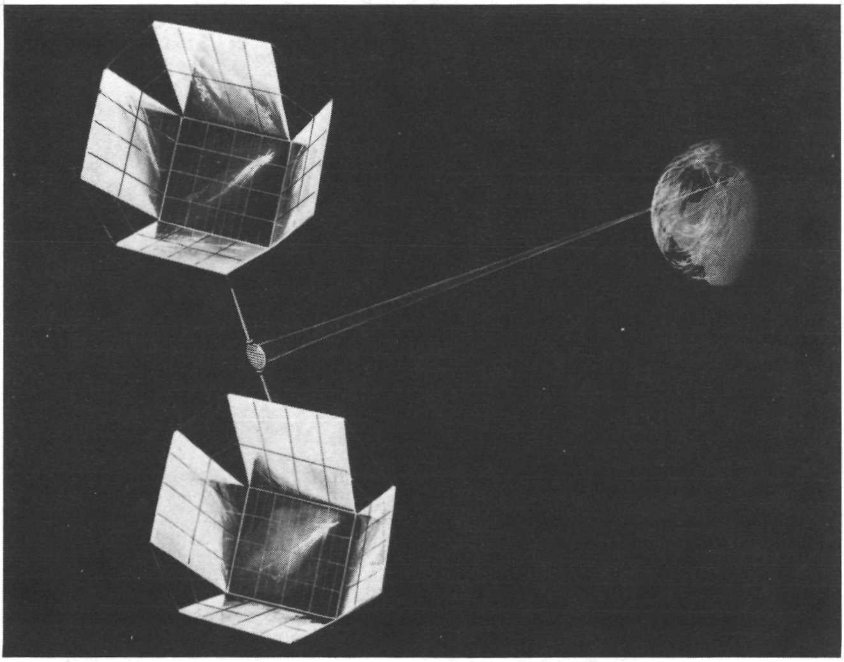


Figure 6. Solar Satellite Power Station Concept

*A satellite at 22,300 miles above the equator orbits the earth in 24 hours. It is thus "synchronized" to earth's rotation and always sees the same area.

Another non-polluter appeared in the Apollo spacecraft where fuel cells combined hydrogen and oxygen to produce electric power without pollution. Forbes magazine reports that the Pratt and Whitney Company has a research contract with 28 gas utilities to develop fuel cells for generating electricity from natural or manufactured gas on-site in homes, hospitals, apartments, and shopping centers. Exhaust products will be harmless (water and carbon dioxide). Fuel-cell efficiency is five times that of conventional generators. There are no moving parts, little upkeep is needed, and the cells operate without noise.

The Chairman of the Illinois Commerce Commission is worried about the market conflict that this may bring on between the gas companies and the power companies. "It's possible," he said, "that they could fight this battle the whole way up to the Supreme Court."[14] Meanwhile, however, the Connecticut Natural Gas Corporation is field testing a 12.5 kilowatt fuel cell in an apartment complex in Farmington (Fig. 7).

Also a non-polluting source of power is geothermal steam. Molten magma at various points in the earth transmits its heat

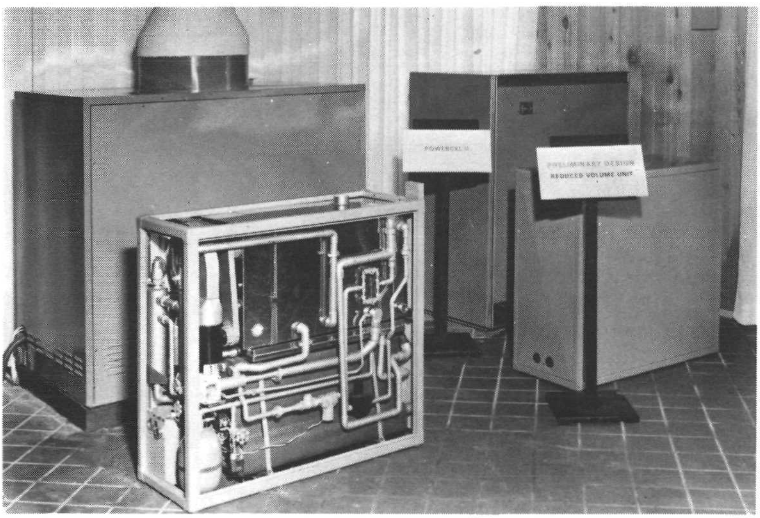


Figure 7. Experimental model of fuel cell designed for generation of electric power in homes. Size is evident from comparison with typical home furnace in background.

This page is reproduced at the back of the report by a different reproduction method to provide better detail.

through solid rock above it to porous sedimentary rock that has captured water. The water boils and escapes upward wherever breaks occur in the rocks. Geysers, hot springs and steam jets result. Italy, Iceland and New Zealand have for decades tapped such steam for power generation. Satellite sensor detection of unusually hot areas or of fault lines indicative of such trapped thermal energy could disclose potential power sources of this type. Such sites can become the locations of new cities, designed for an improved quality of life, and based on clean industry. This is happening at the geothermal site of Cerro Prieto, Mexico, where the Toshiba Company of Japan is installing special turbines, beginning with a 75,000 KW power plant.

Do Your Own Thing

This is not to say that the space program is justified by its solutions to other problems, such as pollution. We need a pollution-solution industry for pollution problems. Space exploration must first have its own purposes and goals.* And it does; for space is being utilized to do things that cannot be done economically, or done at all, in any other way. This is happening, for example, in geodesy, astronomy, geology, navigation, oceanography, meteorology, and communications. The National Geodetic Satellite Program beginning in 1962 learned more in the first few months of satellite geodesy than was learned in the previous two centuries.[15]

The Orbiting Switchboard

The best known economic result of the direct utilization of space is the Communications Satellite Corporation, traded on the New York Stock Exchange as Comsat.‡ Unfortunately, people become accustomed quickly to progress and lose sight of its origin; so, to many of us, the international TV provided via Comsat seems a natural heritage rather than a space bonus. But without satellites, there could be no truly global TV.[16]

In 1963, there were only 500 circuits available by cable for transoceanic phone conversations. Today, Comsat's satellite, Intelsat IV, can alone handle 5000 circuits. A single TV channel is roughly equivalent to 1000 voice channels.

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*For a controversial, alternate viewpoint, see Appendix I.

‡NASA will build no new communications satellites; this new industry is now capable of any further research needed.

Culture, Fads and Horror

Global satellite TV affects society in innumerable ways, some obvious and some vague. Coronations, eclipses, riots, elections, and athletic or cultural events are seen in real time from the other side of the world. The oneness of mankind is thus emphasized as is the concept of one world, and a shrinking world at that. Marshall McLuhan's work, *Understanding Media,* professed the concept of the "global village" which will result from such communications, hopefully producing active awareness of and concern for other men in other places.

"Within this decade," predicts Comsat president Joseph V. Charyk, "electronic libraries in one country could be instantly available to scholars in another. Newspapers, magazines and books, sent by facsimile from central editorial offices, could be published in a dozen distant cities simultaneously. Schoolchildren in developing nations will have available, on command, the most advanced educational materials and techniques."

Fads, fashions, life styles, and behavior patterns (especially of students) will spread more rapidly and widely. The impact on traditional, isolated, or conservative societies will be enormous. Societies which preserve certain values by censoring books and movies may be unable to offset the content of transmissions from neighbors' direct broadcast satellites (Appendix D).

Some sociologists foresee cultural harm from such outside influences. Dr. Charles Osgood, Univ. of Illinois psychologist, believes that people of different cultures are acting more and more alike as the result of modern technology; and he isn't very happy about the possible "homogenization of the human race." What could result is a dull uniformity of mankind from pole to pole.

Issues and worthy causes have an almost immediate international audience. Responses to disasters are improved because sympathetic donors can experience the urgency of live coverage, as in the cultural emergency caused by the 1970 flood destruction of Florentine art. Some believe that the process of withdrawal of American forces from Vietnam naturally followed the withdrawal of the American public from its daily TV broadcast fare: the immediately transmitted horrors of the battlefield. "Certain truths are obviously more palatable in print; the TV watcher cannot digest them without getting heartburn."[17]

Society's Nerve System

Television, however, represents only 2 percent of the workload of the 83-nation Intelsat communications system now

in operation. The biggest payoff has come in direct economic gain to world commerce. Business efficiency has been increased immeasurably by the satellite's ability to provide cheaper and more reliable long-range communications. Before satellites, a West Coast-to-Japan cable circuit cost $15,000 per month; Comsat was soon able to offer this service at a charge of $4,000.[18] Satellite competition, reports COMSAT, forced down the New York-to-London rates for a 3-minute call from $12.00 to today's $5.40. Point-to-point communications satellites have been less expensive than submarine cables, and it is expected that eventually the breakeven distance will be reduced to 100 miles or less.[19]

Undeniably, this incredible communications system is becoming the new nervous system of our global society. As scientist-writer Arthur C. Clarke – whose fertile brain envisioned the communication satellite long before any man-made object was propelled into space – informed the signatories of the Intelsat agreement in 1971: "Whether or not you intend or wish it, you have just signed a first draft of the Articles of Federation of the United States of Earth."[20]

Domesticate the International

Inspired by the success of Intelsat, the Federal Communications Commission recently lifted a long standing ban on private satellite systems and requested suggestions for a U.S. domestic communications satellite system to provide new services (including low-cost message, data, telephone, and television transmissions) coast to coast – and anywhere in between. One of the eight applicants for licenses, Fairchild Industries, says its proposed system can cut the costs of our long-distance telephone service to one-tenth of the existing rates.[21] Because U.S. long distance phone calls total over $6 billion a year ($6,561 million in 1970), it appears that the savings in this area alone could exceed the space program's current budget.

Eight other large firms have also applied. The business potential is very high indeed, because new customers appear every day for communications services: major banks, stock exchanges, law enforcement agencies, hospitals, computer centers, airlines, hotels, and corporations with functions such as inventory, purchasing, sales, shipment, or production-control data.

On August 3, 1972, Western Union Telegraph Co., prior to FCC final approval, announced that it had ordered three com-

munications satellites from the Hughes Aircraft Co. to transmit telegraph signals, data communications, and internal "private line" messages for major businesses. It moved in advance of approval of its license in order to realize savings by buying the same satellite Hughes had just finished building for Canada.[22]

A spokesman for the National Cable Television Association anticipates that cable systems around the country will be interconnected by way of domestic satellites into a national cable network.[23] And due to time zones, communications satellites could enable computers to be used and shared economically around the clock across the nation and throughout the world. Recently, for example, engineers in Argentina, working on a complicated bridge building problem, punched data into a keyboard in Buenos Aires and received solutions a few minutes later from a computer in Massachusetts.

The Invisible Mesh

A synchronous satellite can see nearly half the Earth's surface. This creates the potential for an infinite number of communications connections for every point within the satellite's huge "cone of visibility." It is the equivalent of an unlimited number of crisscrossed cables and land lines which would constitute a global communications mesh. Commercial operations of this equivalent began with the satellite, Intelsat 3-F6. The system is called Multi-Destination Communications. The next operational step, already in use in a few countries, is the Demand Assignment System. It allows a country such as Chad, which has little international telephone traffic, to dial into a pool of frequencies set aside in the satellite and to be connected through one of them to any other country which the satellite can see. Argentina now telephones Peru, and Chile talks to Brazil, for example, where no telephone lines cross the Andes and the jungles.

Copper Versus Air

To achieve these capabilities even partially, the conventional wire and cable methods would have to put millions of additional tons of copper in the ground. The cost of copper would become exorbitant. There probably would not be enough copper to do the job. So here a NASA development is conserving a short-supply natural resource not only for the U.S., but for all nations.

Consider the cost savings! The developing countries will not need the billions of dollars for materials and labor required to set up a conventional system. Their communications network can be achieved in a small fraction of the time normally required.

Consider what this will mean for vast countries like Canada, mountain-strewn countries like Ethiopia, or island-sprinkled countries like the Philippines and Indonesia. A transmit-and-receive earth station that costs about $2 million is the price of admission to the 83-nation Intelsat system. This can connect a nation's existing telephone, television and other services to the outside world. Many nations have achieved a comparable leap in the field of transportation by going directly from ox cart to aircraft, by-passing the historical steps of roads and railways.

Bicycle-TV and Population Bombs.

India will soon be a beneficiary. NASA's Applications Technology Satellite-F is planned for use by the Indian government in 1975-76 to beam mass instructional broadcasts into community TV receivers in 5,000 villages (Fig. 8). India will prepare and transmit the information on topics such as health, agriculture, sanitation, and population control. In some remote areas the TV sets may be powered by batteries charged by solar cells; in other, by men pedaling bicycle-driven generators.

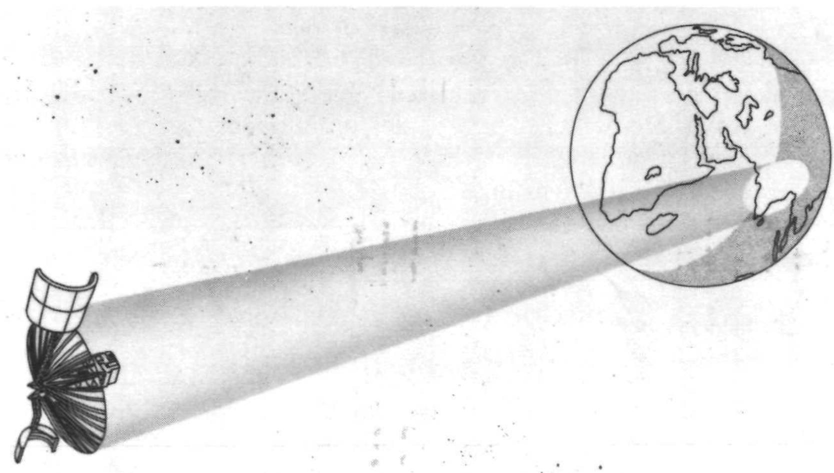

Figure 8. NASA's Applications Technology Satellite-F (ATS-F) communications will beam instructional television programming to more than 5000 Indian villages, beginning in 1975.

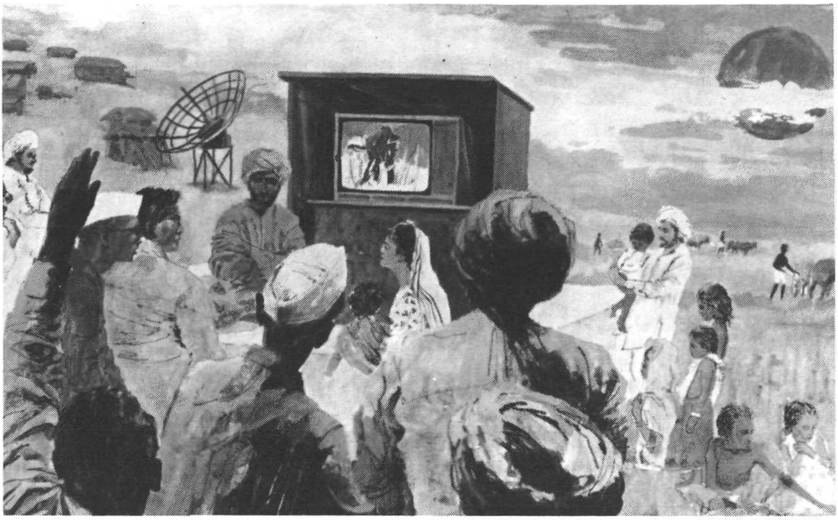

Figure 8a. Artist's concept of a community instructional session in an Indian village. (Courtesy of General Electric Co.)

Emphasis will be placed on family planning, the key to any future for India. The basic concepts will be presented partly by puppet shows in the tradition of the generations of India's traveling puppeteers. Some officials believe that India can stop its population explosion only by mass communications via its own direct broadcast satellite. Only this, they feel, can project the "unique authority and impact of the TV set into every village in the land."

The Good Life in the Bush

People in the developed countries cannot imagine the information starvation experienced by the villagers of a backward nation. The villagers have little or no access to knowledge. Ignorance, superstition, and illiteracy are both causes and results of poverty in a self-perpetuating cycle that runs for centuries. Social planners believe that this cycle can be broken by educational satellite TV.

In some countries it may be the key to overcoming problems of tribalism and of multiple languages. In newly emerging countries it will be important in creating a national cohesiveness.

An article in the London Express described the impact on developing nations, and those with frontiers, in an interesting light: "Men need information, news, mental stimulus and enter-

tainment. For the first time in 5,000 years, a technology now exists which can halt and perhaps even reverse the flow from the country to the city. The social implications of this are profound; already, the Canadian Government has discovered that it has to launch a satellite so that it can develop the Arctic. Men accustomed to the amenities of civilization simply will not live in places where they cannot phone their families, or watch their favorite TV show. The communications satellite can put an end to cultural deprivation caused by geography. It is strange to think that, in the long run, the cure for Calcutta may lie 22,000 miles out in space."[24]

The Mid-Ocean Traffic Jam

In a recent issue, Fortune magazine said: "Because of the absence of mid-ocean surveillance, transatlantic flights must follow a preset course that, for safety's sake, keeps planes spaced 120 miles apart laterally, as against eight-mile spacing over the contintental U.S., with its extensive navigational beacon and radar networks. There is only one shortest and most economical route across the Atlantic between any two points, and as traffic has increased many planes have had to be diverted farther north or south of this route, in order to maintain separation, at added costs in fuel, time, pilots' pay, and other expenses. A space satellite system is the only hope."[25] The economic penalties of non-optimum flight paths will mount as the current 400 aircraft per day average rises to almost a thousand by the year 1980. "This could cost airlines an average of $1000 per flight and by 1980 could total some one million dollars per day."[26]

In January 1971, the White House's Office of Telecommunications Policy directed the Federal Aviation Administration to initiate a pre-operational satellite services system on lease from commercial sources.

Synchronous satellites are proposed because each maintains a direct line of sight with some 63 million square miles of the earth's surface and the airspace above it. Two such satellites spaced some distance apart could provide any properly equipped craft within their view with a precise fix on its position (Fig. 9). In addition, by automatically reading out data from an airplane's instruments, the satellites could relay back to ground control stations the exact identity, position, altitude, speed, and bearing of all craft within their huge cones of vision. Here are all the essential elements of a coherent anti-collision, traffic-control system . . . on a global scale.

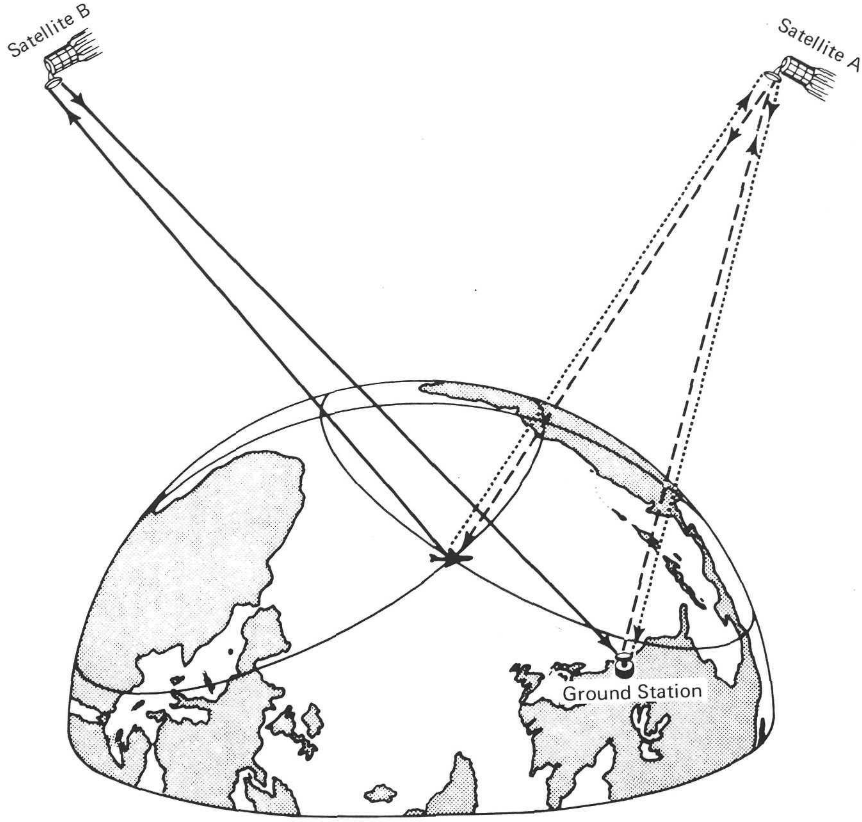

Figure 9. Traffic control system in which two geo-synchronous orbit satellites continuously monitor for ground controllers the progress of a plane in flight. The traffic control of hundreds of aircraft simultaneously will be possible with this method, pinpointing locations to within a mile.

"This is Your Captain Not Speaking"

Millions of passengers have been unaware that "modern aircraft continue to operate in transoceanic areas with marginal high frequency communications".[27] This means that there are periods of no radio contact with the ground. If an emergency forced a plane to ditch at sea it could be an hour or more before ground control is aware of any trouble. Such delay would add to the hundreds of thousands of square miles which would nowadays have to be searched. A satellite surveillance system would not only pinpoint the aircraft location within a mile, but its reliable communications could conceivably allow air/sea

rescue teams to be on the way even before an aircraft in distress had hit the water. NASA's applications satellites have already demonstrated the feasibility of uninterrupted communication with transoceanic aircraft in paving the way for an operational system to improve public safety.

Satellites of the Sea

The Merchant Marine has begun to capitalize on satellite advantages. Recently, the IT&T Corporation installed in the British cargo liner, Prometheus, the system utilizing the TRANSIT navigation satellites which the U.S. Navy and the Royal Navy use to position ships to within a quarter-mile. Britain's Nautical Advisor to Ocean Fleets, Capt. A. C. Sparkes, says: "This new type of satellite navigator will pay for itself in one to three years through the saving of time and fuel." The U.S. Department of Transportation has ordered a study to determine the cost of adding a navigation and/or a position surveillance capability to a satellite system designed primarily for maritime communications.

The Comsat Corporation is experimenting with the Cunard Line's Queen Elizabeth 2 to prove the feasibility of establishing a high quality and reliable 2 way communications link from ship to ship or to shore stations. It could improve shipping management, safety and passenger service. The Queen carries an 8 foot parabolic antenna for communicating via Comsat's Atlantic satellite INTELSAT IV (Fig. 10).

Exxon and Sun Oil Co. engineers are investigating with NASA the feasibility of precisely locating by satellite the Gulf Stream and other powerful currents which meander daily. The warm Gulf Stream shows up clearly on an infrared photo from a weather satellite. If ships knew the location of its core, they could ride it going north and avoid it going south. The U.S. Maritime Administration is exploring with NASA an experiment to utilize satellite weather photos transmitted to commercial ocean vessels. The stakes are high: avoidance of the delays, hazards, and damage of storms, plus speed of passage via currents.

Senator Mike Gravel of Alaska has said that he will ask NASA to include an ice monitoring system into the NIMBUS program and that he may press for compulsory use of TRANSIT navigation equipment on every tanker serving U.S. ports. He believes, "We could improve navigational accuracy on the high seas by a factor of ten, and accuracy means safety and less chance for collision and pollution."[28]

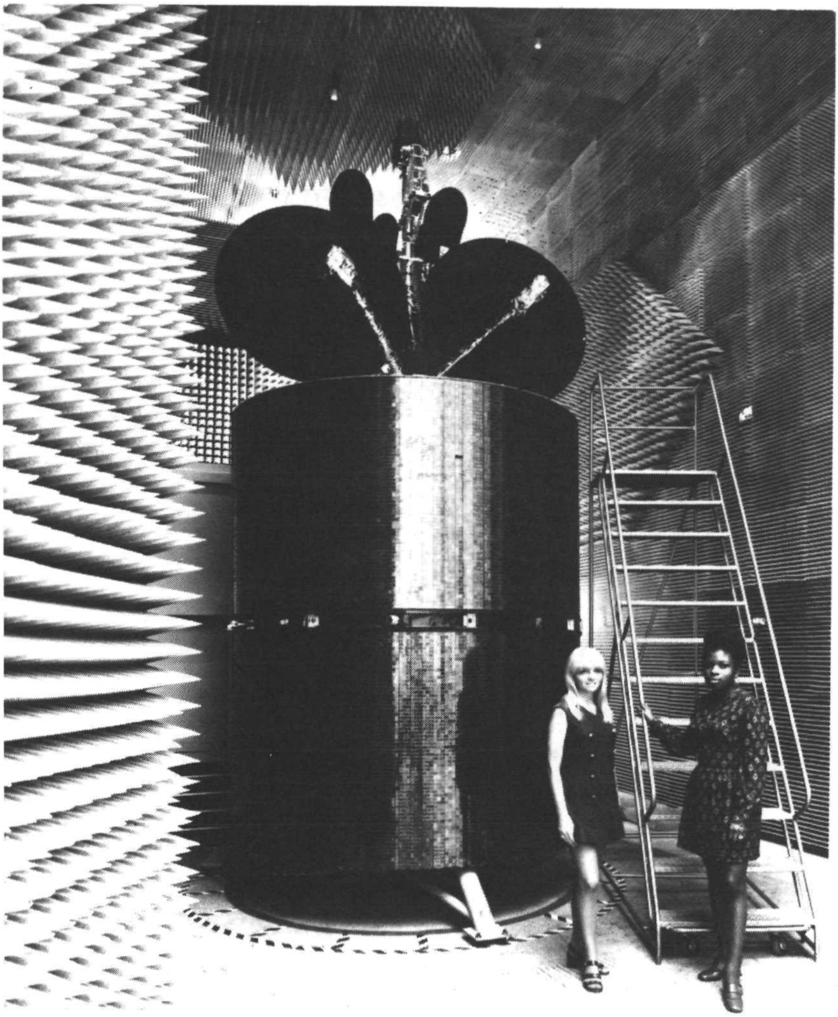

Figure 10. An Intelsat IV generation satellite, with dimensions approximately 18 feet high and 8 feet in diameter and weighing almost 3100 pounds.

People in Fire

In the area of public safety society is being affected in numerous other ways. For example, NASA recently showed the results of its fire prevention research on 3200 non-metallic materials by demonstrating hundreds of fabrics, coatings, and other substances that will not burn. They are finding use in protective clothing, hospitals, building materials, aircraft, and

automobiles. In one test, a C-47 fuselage was placed in a pool of burning jet fuel to simulate a crash condition. The forward section had conventional insulation, while the rear test section had NASA-developed foam insulation (polyisocyanurate). Within 2 minutes, the air temperature in the forward section was above 500°F. In the NASA section it was about 100°F. After 5 minutes, this section was still under 150°F. The Avco Corporation, which conducted the tests for NASA, reported that the application "of the foam to passenger aircraft will dramatically increase the time for rescue and survivability."[29]

The need for such NASA-developed knowledge was highlighted in Congressman Robert Steele's testimony before the National Commission on Fire Prevention and Control when he said: "The United States experiences a per capita death rate from fire that is twice that of Canada, four times that of the United Kingdom, and six-and-a-half times that of Japan."

The Issue of Intellectual Hostility

Shortly before his death Bertrand Russell applauded the skill and courage of the moon flights, but doubted that they would contribute to wisdom, thought or enlightenment. "It is for us to grow to the level of the cosmos," he wrote, "not to degrade the cosmos to the level of our futile squabbles." British historian Arnold Toynbee compared the moon landing to the vain building of the pyramids or the palace of Louis XIV at Versailles. He lamented man's staying "practically stationary in morals and social behavior, while so marvelous in his technology." Philosopher-historian Lewis Mumford complained that we should be exploring not space, but "the innermost recesses of the human soul." Such spokesmen imply that man would somehow be a better creature if he had not gone to the moon; or that he should have tried to become a better creature by doing some other (unspecified) activity in place of going to the moon.

The literary world's "almost total recoil from the Space Age" plus the attitudes quoted above spell out at least a non-endorsement of the space program by the intellectuals. Social critic Thomas Wolfe takes it further, describing "the phenomenon of the intellectuals' amazing hostility to NASA's success in reaching and exploring the moon."[30] He believes, in fact, that Norman Mailer's lengthy book *Of a Fire on the Moon* was actually "an announcement that the whole enterprise was sterile." Writer Edwin McDowell summarizes, "What Mailer and

other critics, home and abroad, were really saying, according to Mr. Wolfe, is that these nonintellectual Americans may have accomplished a feat – but the feat was worthless."[31]

And so the argument sizzles, with opponents driven to extremes of opinion. Columnist D. J. R. Bruckner declares, "If all we get from them is knowledge, science research budgets will suffer. We have trimmed away the funds for scientific research, for high energy physics, for space research. Americans will stunt their understanding and lop off pieces of their minds to save money. This is the economizing of brutes and barbarians. I, for one, would rather be counted a citizen of that nation which opened up the heavens and sent men to the moon than one of a nation which built more highways than any in history, or was richer than any in history, or which . . . at unspeakable cost, went to Vietnam."[32]

Response of the Artists

"The camera sees everything and understands nothing," believed Honoré Daumier the great 19th century artist. NASA came to appreciate the significance of this statement early in its history. Although several hundred cameras recorded every instant of activity during major launches, the photo record had captured only the cold facts. NASA Administrator, Dr. Thomas O. Paine, observed ". . . the emotional impact and hidden meaning remain within the scope of the artist and the poet." He concluded ". . . . we have a solemn obligation to leave for future generations a truthful record at all levels of perception, and for this the imagination and insight of the artists are invaluable assets."

NASA acted on these beliefs in collaboration with the National Gallery of Art, and began an effort to create an artistic record of American space activities. Dozens of America's foremost artists were invited to the centers of NASA activity and had carte blanche to sketch and paint whatever interested them. They functioned on a slightly more than expenses-only basis, although some of these were people whose paintings sold in the $60,000 bracket. All paintings became the property of the space agency and many are included in a large exhibition sent on tour of the U.S. by the Smithsonian Institution.

Several who were invited did not participate. Regarding his invitation, one artist said in a Life interview ("Tom Benton at Eighty"): "I just put it out of my mind. What can I do to make a painting of a damn rocket? You'd show it better in a moving

picture." Benton elaborated on his feeling: "The harmony man had with his environment has broken down. Now men build and operate machines they don't understand and whose inner workings they can't even see. That is why I still prefer the esthetics of a steam engine to a jet plane, or a Model T to my own car. You could observe the insides of these machines. Their parts hung out all over the place and you could see them work against each other. When you can't see something, how do you expect it to move you emotionally?"[33]

The artists who participated prowled launch facilities at Cape Kennedy, lived the mission control dramas at Houston, observed Apollo recovery operations at sea, and visited the test facilities at the Goddard Space Flight Center. Their works were assembled in a large book entitled *Eyewitness to Space* (H. N. Abrams, Inc., Publishers, N.Y.) by Hereward Lester Cooke, Curator of Painting at the National Gallery of Art. The artists are described as varying ". . . from the most conservative to the most avant garde, yielding a fantastic range of sensibility and imagery." They included men with styles as diverse as Robert Rauschenberg, Jamie Wyeth, Norman Rockwell, and Dong Kingman.

It has been said that the artist is the weathervane and prophet of history in the making. The Director of the National Gallery of Art, J. Carter Brown, explains, "He records what he sees, adds what he knows, remembers and feels, and thus immeasurably expands our knowledge." Mr. Brown feels that the unique insight of the artist on-the-spot captured the essense of earlier momentous events, many involving exploration from the 17th to 19th centuries. The artistic, historical and social values were very clearly expressed by Mr. Cooke in his orientation for the artists (Appendix J).

The artist responded and left a legacy of sensitive and perceptive impressions of one of history's great achievements through the intimate, human medium of his eye and hand.

Where Are the Poets?

One of the most perplexing aspects of the exploration of space is its minimal influence on literature, especially poetry. In 1963, Newsweek stated, "The literary world has its own explanations for its almost total recoil from the Space Age. 'More has to happen,' says Stephen Marcus, assistant editor of the Partisan Review. 'We have to land a man on the moon before the writers can go ahead. It's still machines. It's got to be humanized.' "

Numerous lunar landings have since occurred but, with one or two exceptions, the writers did not "go ahead." Yet the ingredients for epic poetry were at hand. Mythology was equalled and exceeded. Man rose toward the Sun on a column of fire. Automatic creatures took wingless flight through the dust of Creation to explore other worlds. Men fell day upon day toward the planet. Spacecraft circled us amidst vast silences and spoke a telemetered tongue. Voyagers struggled home aboard damaged vessels meteorically ablaze. And from the poets, years of silence.

An explanation is ventured by the eminent poet, Josephine Jacobsen. She is the current Consultant in Poetry, situated at the Library of Congress. Her objectivity is apparent; a recent work is "The Planet" *(Best Poems of 1970,* Pacific Books, Palo Alto, Calif.). "Writers," she believes, "are all tied up with human beings. In contrast, most writers I know see space activities as the result of a government program, not in terms of an adventure of the human spirit. To them space flight is not an achievement like Lindbergh's; it's more like something done by a corporation. Incredibly, some of them do not even feel that there is someone pushing back the limits of science.

"In addition, they are against spending money in this way, and they sense military implications. This makes them disillusioned and hostile. There's also the inevitable impression that we're going on to other things, elsewhere, instead of remedying the mess we've made of this planet.

"Now it's quite understandable to poets that the painters have expressed their emotional response to the visual impact of space activities, because painters can do it free from all verbal arguments. There is no appearance of endorsement, there is no verbal involvement in the program, and there is no suggestion of political docility."[34]

Admittedly, all space flight nowadays is part of some government's program. And avoiding the status of captive poet is, of course, of urgent importance. (In fact, such a creature seems impossible, a contradiction.) But no subject is outside the poet's domain, and none may be verboten. Yet on the subject of space, with a few eloquent exceptions, the poet spoke neither for, nor against, nor about. And so, to the explanations above, perhaps another should be added: the obstacle of an extremely technical activity and its language. Perhaps validating this thought is the considerable poetic expression during this same period by people steeped in the action . . . space employees. They published repeatedly in their house organs and trade

magazines. These reputedly unemotional technical people saw beauty in their exploring machines, a new breed of vessel, and saw mystery in their destinations (Appendix K).

This is a complex, troubling phenomenon. It puzzles Karl Shapiro, Pulitzer Prize poet: "You would think that the poets would be the first to leap in delight at such apparitions as television and missiles to the moon . . ."[35] Additional explanations for the non-participation may emerge with time. Meanwhile, it continues perplexing to believe that a poet would ignore lunar pioneers Armstrong and Aldrin as subject matter because they were government-funded. On this basis they could eliminate Lewis and Clark. In related correspondence, poet Archibald MacLeish reasoned, "What these people are saying is that current intellectual fashions are anti-Establishment and that most writers accept the fashionable intellectual rule. Which is possibly true – but doesn't change the fact that current intellectual fashions are bad for writers. Take the anti-Establishment cliche and apply it to the background of myth out of which all truly creative work comes. Who ran the expedition against Troy? What was Odysseus? Lear? No, the trouble with the space voyages as material for poetry is not that 'the government' pays for them (who paid for Columbus?) but that the voyagers serve not only as explorers but as guinea pigs. But that only means that the voyage is exploration in more directions than one. Poetry needs to step back a step and see the whole – *a man in space*. Will it reject that perspective because it rejects 'the Establishment'? I think it improbable."[36]

Mark Twain Was Wrong

A humanitarian application of satellites lies in weather forecasting. The weather satellite's greatest boon to date is its ability to save human lives by a forewarning of destructive storms. Before the satellite, a storm could frequently be born unobserved at sea and sweep into an inhabited coastal zone without warning, driving a wall of water before it, and wind-ripping towns into kindling. Despite the weather satellites which the U.S. is now flying, disasters still can happen in countries where communications systems are insufficient to carry the warnings. In November 1970, a cyclone struck Pakistan at the Ganges River delta and flattened thousands of heavily-populated offshore islands, killing more than 300,000 people.

The U.S. itself narrowly averted massive tragedy in 1969 from Hurricane Camille, a storm carrying 200-mph winds that

did hundreds of millions of dollars' damage. The weather service estimates that 40,000 lives would have been lost without early accurate warning of Camille's path. Satellite photos gave the warnings immediacy and believability, and convinced people to evacuate. The death toll numbered hundreds, not 40,000.

Not Since Noah

The National Geographic magazine, in describing the values of weather satellites, included predictions of floods and said "Not since Noah has man had such authoritative warning of high waters to come."[37] The satellites observe the extent of snow buildup and send the information to computers which estimate the impending runoff.

Such satellite warning permits flood control reservoirs to be lowered in advance to provide storage space. There is no way to identify, let alone evaluate, the damage prevented and the lives spared in a flood that did not occur.

The Ten Thousand Probes

Weather is a global process. It *requires* satellite observation. Nothing else will allow development of the understanding we need to achieve long-range weather forecasting ability (Fig. 11). The recent Nimbus III satellite proved the practicality of acquiring vertical profiles of temperature and water vapor measurements of the atmosphere. It provided every day, electronically from orbit, the equivalent of 10,000 conventional atmospheric probes by rocket. As a result, there are improved wind analyses for the increasing numbers of aircraft flying in the stratosphere.

Big Synch is Watching

The ultimate weather view awaits the synchronous meteorological satellite (SMS). It will always watch the same large region of earth. Goddard Space Flight Center has contracted with the Philco-Ford Corporation to produce such a satellite for operational use by the National Oceanic and Atmospheric Administration in 1974. It will provide advantages to meteorologists by letting them study the actions of entire weather systems.

APT and the High School Wizards

Meanwhile, the current weather satellites beam down their immediately broadcast APT photos (automatic picture transmis-

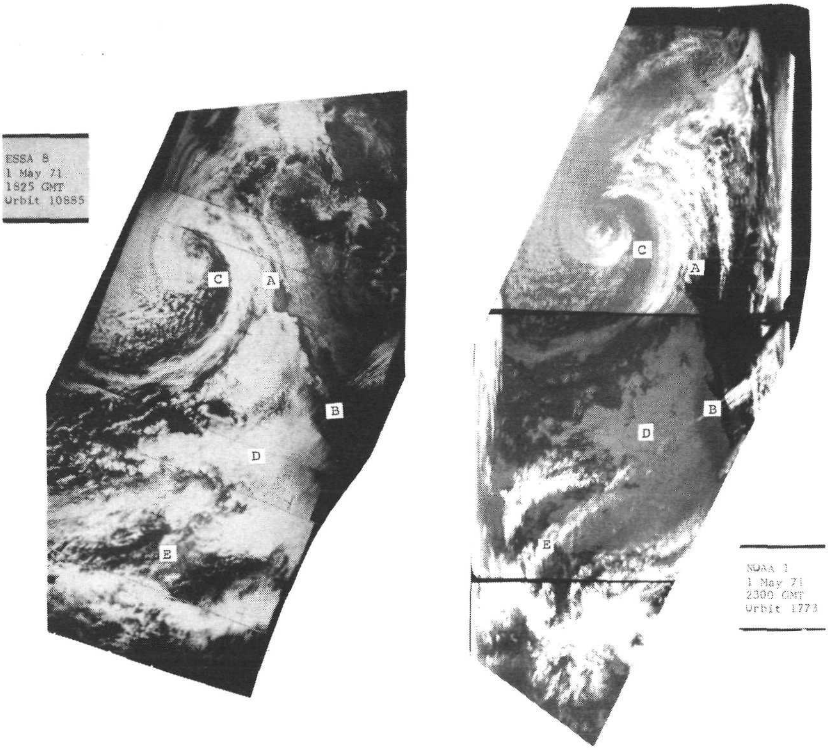

Figure 11. Two views from space of the same region at approximately the same time. On the left is a visual (TV) image; on the right is an infrared (heat radiation) image. Recognizable land masses are (A) California, and (B) the Baja California peninsula, Mexico. In comparing these images, note the dramatic intensity differences in the (C) cyclone, (D) cumulus cloud cells, and (E) "pipeline" cirrus clouds. The high, thin, cirrus clouds (E) are almost invisible in reflected light (ESSA 8); however, they appear bright (being high-altitude, cold clouds) in the infrared image, better enabling the meteorologist to analyze and predict weather.

sion), in visible light and infrared, to over 50 countries who thereby learn of the daily weather patterns over their own territory. These nations thus profit from improved air traffic routing, marine navigation, water management and protection or evacuation of threatened areas. APT pictures are received on portable oscilloscope sets costing under $10,000, including the antenna. Some high school weather clubs have built sets for about $400, working from a publicly available NASA document (NASA SP5080).

Navy aircraft carriers equipped with APT sets accomplish more flight training per cruise because they lose less time searching for cloud free areas acceptable for practice exercises. APT photos could also help a vessel hide from aerial reconnaisance and locate relatively calm areas for rendezvous points to transfer supplies, fuel, and men at sea.[38]

Sea Ice and Raisins

A fascinating operational use of weather satellites is their ice mapping capability. The Fleet Weather Facility has global responsibility for forecasts of sea ice conditions for the U.S. Navy. Its director told NASA, "The Nimbus IV satellite imagery provided to this command by NASA is of inestimable value. Our ice forecasters, using your product as a base, are just now concluding a successful season in the Antarctic with no reported ice damage to shipping."[39]

Direct cash savings are occurring because satellites are improving weather forecasting. Consider the San Joaquin Valley of California where the raisin crop is worth $100 million. Each September it must be sun dried (Fig. 12). If more than a tenth of an inch of rain is forecast the drying raisins must be covered. This costs from $100 to $200 thousand – a significant percentage of a year's profits, and it requires up to 24 hours advance notice. Satellite data is an essential ingredient in improving forecasting reliability in that area.

Preparations and Other $

Areas which lie in the path of a hurricane must take extensive precautions to minimize damage. For the city of Miami alone, the preparation cost has been calculated at two million dollars for a single storm. Satellite photos minimize the possibility of false alarms and their exceedingly high costs.[40]

Savings also occur in aerial photo mapping where satellite weather photos have increased the productivity of mapping teams by 200 to 300 percent. Such mapping requires accurate predictions of clear skies over flight tracks of 50 miles or more in length, and only the satellite can provide that necessary knowledge. One such project in Ethiopia was finished a full year ahead of schedule because of guidance by satellite pictures, and with cost savings that exceeded $5 million.

Observations of the weather in the oceans and sparsely inhabited land areas surrounding the United States, impossible

Figure 12. Raisins drying in the sun, San Joaquin Valley, California.

before the advent of weather satellites, should lead to a quantum jump in the accuracy and range of weather forecasts.

Large savings through improved weather forecasting can be expected in the weather-sensitive sectors of the U.S. economy, because the volume of business in these industries is substantial. In agriculture, transportation, construction and roadbuilding, for example, the total annual volume in 1970 was about $270 billion, and estimated losses due to weather were in the neighborhood of $13 billion. A relatively modest reduction of 20 percent in these losses would correspond to a $2.6 billion savings. These circumstances lie behind the estimate of important gains to the U.S. economy from this single application of space technology.[41]

Spawning and the Delivery Anomaly

Some of the offspring of space research take on a momentum, growth and direction of their own, yet they continue indefinitely dependent on NASA, the spawning organization. This occurs because they have no satellite launching capability. The Comsat Corporation is in this situation for its commercial

communications satellites, as is NOAA* for its weather satellites. Other agencies and corporations are scheduled to follow: for air traffic control, for navigation, and for the U. S. domestic communications satellites. Foreign nations and consortiums (e.g., ESRO*) are selectively provided launch service. Note that half of the scheduled NASA launches for 1972 are for other organizations than NASA (Appendix L).

An anomaly emerges. NASA, created to research and develop so that others might use its results operationally, has thus itself become operational. This is welcome at the launch sites for it increases experience and the use of facilities. Of significance to society is the development of an orbital delivery service, available for the benefit of science, commerce, communications, resources management, and public safety to government agencies, corporations, and friendly nations. Compensation for this specialized, highly technical service goes by law to the Treasury Department and cannot be used to reduce the NASA budget (Appendix M).

The Allocation of Talent

Views clash on where the technical talent of the nation would be best employed. Nobel Prize physicist Max Born said, "There is the claim that a country which does not take part in space travel will remain behind in all these areas (electronics, fuels, metallurgy), and will not be capable of competition. Against this stands the fact that the technique of space travel absorbs a high percentage of available brainpower and withdraws it from other purposes. It is questionable whether the damage thus inflicted upon the overall economy is balanced by the benefits. A pure blessing seems not to be hiding here."[42]

This opinion seems to be supported by certain comparisons: "One recent study showed that eight European countries whose combined Gross National Product was one-third that of the U.S. had three times as many engineers, scientists and technicians engaged in civilian-oriented R&D. Comparisons between the U.S. and Japan are even more striking."[43]

Vigorous dissent is voiced by those who believe that space-developed technology will permeate industrial society. One defender asks, "Do they really believe that scientists, engineers and managers in other areas are not going to avail themselves of

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*NOAA, the National Oceanic and Atmospheric Administration
ESRO, the European Space Research Organization

new scientific knowledge, new alloys, and new ways of working them, new inventions, new devices for refining tolerances and upgrading standards, new techniques for radically improving management? Do they really believe that these new and advanced things required to be taught and learned in graduate schools and research centers and industry will be put to use only by those who actually go into aerospace careers? History has always proved the converse to be true. The effect of straining, reaching and developing new muscle and sinew in a particular focus of technological advance has always proved, sooner or later, to be all-pervasive."[44]

This dissenting opinion emphasizes that the talent and technology actually is available in America but is inadequately utilized for domestic products, pointing out that "Between 50,000 and 65,000 engineers and scientists are unemployed in their own fields as a result of aerospace and defense layoffs, high academic output, scarce research funding and the sluggish economy. Unless national policies change, says a new National Science Foundation report, there will be a surplus of 41,700 Ph.D. engineers and Ph.D. scientists alone by 1980, not to mention lesser degree holders."[45]

"The City That Waits to Die"

Thus titled, a Time-Life documentary film explores San Francisco's earthquake history and prognosis. San Francisco, astride the infamous San Andreas fault, is a wing-walker among cities, casually doing ordinary things in an extraordinary setting. Her citizens accept the inevitability of serious, perhaps disastrous earthquakes to come. They intend to rebuild if necessary. That requires survival, which requires evacuation, which requires advance warning. But no pre-quake detection system exists. However, a current satellite experiment is designed to seek indicators.

Current theory about the surface of the earth sees it as a series of continent-sized blocks (called tectonic plates) slowly moving past each other. Where these plates are in contact with each other, a fault or fracture in the earth's crust exists. On the eastern side of the San Andreas Fault the continental U.S. is thought to be moving southward at a rate of 3 to 4 centimeters per year with respect to the other side. When friction along the fault impedes the local movement of tectonic plates, the energy of the plates' motion is stored along the fault until the frictional restraining forces are overcome and the earth's surface along the fault line "snaps" to a new position. This happened in 1906,

producing the disastrous San Francisco earthquake. Since that time, that section of the San Andreas Fault has been locked and strain is again being stored.

NASA will conduct this experiment and provide the data for analysis and utilization by the U.S. Geological Survey, the National Oceanic & Atmospheric Administration and Columbia University scientists. They hope to measure to a precision of a few centimeters the distance between two widely separated points (about 600 miles) at opposite ends of the Fault and on opposite sides. By simultaneously measuring the distance to a passing satellite from these two laser tracking sites, the distance between the two sites can be calculated more precisely than by conventional methods. Repeating this measurement over several years will enable the relative motion of the two tectonic plates on either side of the fault to be determined. This information will be important in the study of the relationships between slippage, rate of energy storage and energy releasing along a fault. Hopefully it will contribute to our eventual alleviation of some of the problems of earthquakes.

The Management Push

Management skills are basic to the productive strength of a country. These have been tremendously advanced in the U.S. by the space program. New management systems are now available to us for planning and controlling the millions of actions required over a period of years by thousands of people on any large project the nation may undertake. Revolutionary computer-based developments have been achieved to implement these systems, including equipment, mathematical techniques, and programming languages.

Ford Taps the Bank

Hundreds of the resulting adaptable computer programs have been sold to American industry at a fraction of their original development cost by NASA. They are available from COSMIC, the computer program bank at the University of Georgia.

The Ford Motor Company purchased from COSMIC a NASA-developed stress analysis program called NASTRAN and is using it in the design of its vehicles, especially on steering linkages and suspension systems. This program analyzes stresses in complex structures under load, heat and vibration. Ford calls it "an extremely powerful tool," which has so far achieved a

60% improvement in accuracy and detail, and a 2/3 time saving for calculations predicting the behavior of components under stress. Ford has reported a savings of $12 million per year from NASTRAN.

It's the System

Space developed "systems engineering" techniques are now being applied to the design and development of tasks in non-space fields. The laser cutter for the clothing industry, for instance, was achieved by a systems engineering team which investigated 42 methods of doing the job. The tools of system engineering include analytical techniques, systems modeling, requirements specifications, design reviews, and test programs. The method is being used to design hospital complexes, improve law enforcement, reorganize court procedures, develop transportation systems, distribute electrical power, and design such systems as the 500-mile project for moving water from Northern to Southern California. The non-space needs will be met sooner, cheaper, more effectively, and more reliably because of the systems engineering approach developed for space requirements.

Bearing the caption, "The North American Rockwell Co. – Where Science Gets Down to Business," a center fold ad in Time Magazine told one of the results of the "systems engineering" story this way:

> "Heard what happened when the people who helped put men on the moon began exploring the textile and fashion industry?
>
> "They built a new kind of knitting machine – Electro-Knit 48. But this is no ordinary run-of-the-mill knitting machine. Every one of its 1700 needles is electronically controlled. It can change patterns in the few seconds it takes to change a computer tape – faster than a girl can change her mind, or her outfit. It gives textile mills greater flexibility, larger patterns and quicker response to the market than ever before.
>
> "ElectroKnit 48 was developed by engineers from our Textile Machinery Divisions working directly with systems engineers from our Electronics Group."

Shock and Follow On

In the field of education, the benefits of space research are profound and continuing. A bonus for the educational system of

the U.S. resulted from the Russians' many space firsts. Their Sputniks burst on an astonished world with all the impact of a psychological atomic bomb. Nationwide fear and embarrassment resulted, and American educators responded and improved our scientific educational practices at all levels. Curricula changed. New maths and physics appeared. Instruction in other sciences was radically altered and updated. American policy makers passed the National Defense Education Act of 1958 in an attempt to improve the educational system. The support from throughout the nation was so strong that it withstood the agonies of massive educational restructuring and the cost.

The Four Year Book Gap

NASA actively disseminates its research findings to educators, short-cutting the 4- to 5-year gap from discovery of new knowledge to appearance in a textbook. In the January, 1970, edition of *Social Education*, the periodical of the National Council for Social Studies, is this statement: "The curriculum publications of the National Aeronautics and Space Administration (NASA) are far ahead of anything educational publishers have produced."

In addition, the research facilities of U.S. universities have been substantially improved. In the 1960s, NASA grants funded the building of research centers at 34 institutions for work in space science, materials research, biomedical investigations, and propulsion studies.[47]

Link Rio Grande do Norte

The prospects for reducing illiteracy in every society of the world have been brought decades closer because global educational television via satellite is now possible. A request from Brazil is now under evaluation by NASA for a year's experimental use of ATS-F to directly broadcast classroom instruction into 500 schools throughout the state of Rio Grande do Norte in the northeast corner of the country. An operational system of this type could help overcome a severe shortage of teachers in sparsely populated rural areas.

Dr. Arthur C. Clarke concludes, "The emerging countries may need rockets and satellites much more desperately than the advanced nations which built them. Swords into ploughshares is an obsolete metaphor: we can now turn missiles into blackboards."

Tune to 2.5 GHz

In Geneva, in the summer of 1971, the World Administrative Radio Conference considered frequency allocations for a wide variety of space applications. Especially significant was the allocation of 2.5 GHz for educational purposes. The implication is that educators and government officials are preparing for significant educational uses of communications satellites. The planners are mobilizing. For example, the University of Wisconsin has created an educational satellite center (dubbed EDSAT) for multi-disciplinary study of the satellite's educational and social applications, and to develop hardware, systems, methods, programs and models to most effectively utilize satellite broadcasting potential.

The way is also being paved by experiments by Dr. S. P. Marland, Jr., Commissioner, U.S. Office of Education: "In the first experiment we have established a unique two-way radio hookup to assist teachers in 21 remote native villages in Alaska to improve both their own skills as well as the educational fare they can offer their pupils. Actual transmissions by means of a NASA satellite (ATS-1) began late last month, providing these villages, most of which are without telephone service, a combination of in-service training and other support for teachers as well as the means for conducting forums on educational health and native cultural topics. The teachers can also use the communications system mutually to reinforce their performances by talking to each other from village to village as well as to a central source of consultants located in Fairbanks.

"We are also planning to use another NASA satellite, a somewhat more complicated device that is scheduled to be launched in March 1973, for experimental educational telecasts and broadcasts to remote areas of the Rocky Mountain States, many of which are inaccessible to conventional educational broadcasting."

The New Vantage Point

In the field of science, spacecraft have given investigators what can only be described as "a new vantage point" (Appendix N). Without it we would be unable to conduct much of the startling new research in radio astronomy, X-ray astronomy, and high energy physics. Vast gains in knowledge have already occurred and may find practical application in the near future. For example, here is a portion of an interview with the volcano and earthquake scientist quoted earlier – Dr. Goles.

QUESTION: "What difference does it make, for instance, that we can now measure the distance to the moon with an accuracy of one foot rather than the previous accuracy of a quarter-mile, thanks to the emplacement of a laser beam reflector on the moon?"

GOLES: "It makes a great deal of difference. If we measure the distance to the moon from other points in both Europe and North America, and then repeat those measurements in 10 years, we'll know for sure whether or not the continents are drifting apart. Such direct observational confirmation of the theory would give us a great deal of confidence in some other things that the theory suggests about the structure of the earth. We might, for one thing, gain a better understanding of some of the mechanics behind earthquakes and volcanic activity, and I think anyone would agree that a better understanding of just those two things would be of very direct importance to humanity."

Lunar Dust and Planet Gases

Concerning the moon, experiments at NASA's Lunar Receiving Laboratory showed that lunar dust mixed in ordinary soil stimulates many plants to grow faster and several times larger.[48] This action of the moon dust has dramatized the importance of trace minerals in metabolism and is rejuvenating experimentation in this aspect of plant nutrition. The motivation is timely, because fertilizers can take us just so far in increasing the world's food production.

Conversely to this spur to plant life, the lunar dust has proven lethal for certain types of earth bacteria. The mechanism for producing this effect is not yet known.

In studying the atmospheres of planets, NASA is trying to learn how they became what they are. Our own atmosphere is changing and we need to know what we are doing to it. For example, in the last 70 years the amount of carbon dioxide has increased 8 percent. We need to know what the effects may be from such changes, and what controls may be needed. We need some very smart people thinking about planets, knowing what *has* happened to planets, and what *can* happen to planets. The possibility of subtle, gradual atmospheric changes reaching a point of irreversibility may exist.

"Uhuru" and The New Astronomy

Space flight is giving astronomers powerful new tools such as NASA's Orbiting Astronomical Observatories (OAO series), because satellites provide the only practical means for making full-range observations in the radio, infrared, ultraviolet, X-ray, and gamma ray wavelengths. Some wavelengths are blocked by earth's atmosphere. The knowledge gainable by observing stars in ways other than by visible light at ground level is dramatized by comparing photos in different wavelengths of the same area of the sky (Fig. 13). The satellite "Uhuru"* recently found a star in the Milky Way that pulses X-rays for nine days and then stops pulsating for 27 days.

Some stellar objects emit energies at prodigious rates, suggesting that we may be witnessing new, powerful modes of energy production very different from those we know about. Newsweek magazine gives an idea of these energies, saying, "The power of a quasar is to an H-bomb what an H-bomb is to an ordinary light bulb."[49] Recalling that our present-day knowledge of nuclear energy stemmed from studies into how the sun operates, we can speculate that satellite astronomy may eventually yield results of practical importance.

In his speech accepting the 1970 Nobel Prize for his work in plasma physics, Swedish-born scientist Hannes Alfven predicted that the direct study of plasmas in space is likely to lead to the ability to achieve control of thermonuclear fusion power, an ability currently eluding earth-bound scientists.

The Pursuit of Excellence

In 1907, William James said in an address at Radcliffe College, "Democracy is on trial, and no one knows how it will stand the ordeal . . . What its critics now affirm is that its preferences are inveterately for the inferior . . . elbowing everything superior from the highway; this they tell us is our irremediable destiny." James did not believe this doctrine, but he knew that free men, men not driven, must drive themselves to high standards or their society will not survive. John Gardner, in his book, *Excellence*, says it very well: "The importance of competence as a condition of freedom has been widely ignored (as some newly independent nations are finding to their sorrow).

*The Swahili word for "Freedom." One of the Small Astronomy Satellite (SAS) series, it was launched from a sea platform in the Indian Ocean, off Kenya, for an equatorial orbit.

Figure 13a. The dramatic difference between these two photographs, both of the same star cluster in Sagittarius (M8), taken in yellow light (Lick Observatory Photos).

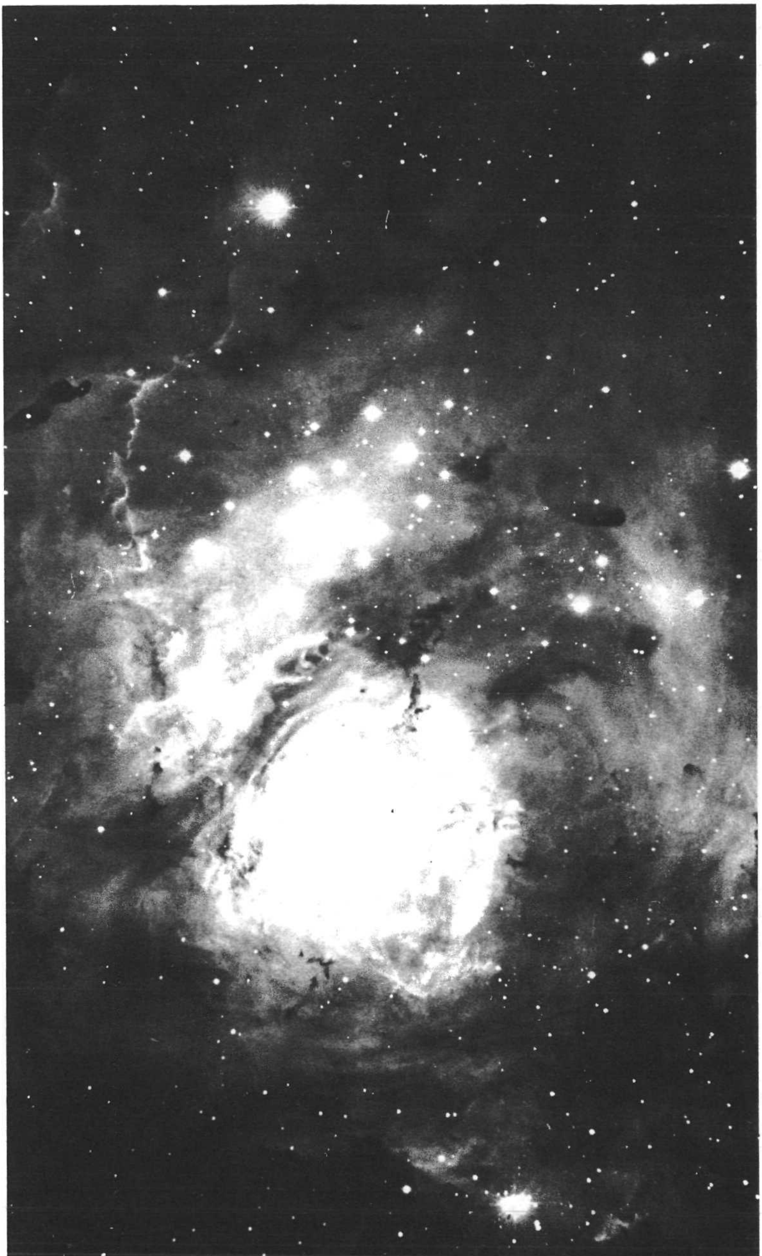

Figure 13b. The same star cluster in Sagittarius (M8), taken in ultraviolet light which emphasizes the gaseous content of the region – gives only an indication of the results to be gained from satellite astronomy (Lick Observatory Photo).

In a society of free men, competence is an elementary duty. The idea for which this nation stands will not survive if the highest goal free men can set themselves is an amiable mediocrity."

Fortunately, this nation has repeatedly set difficult goals for itself, and free men have indeed been their own hard taskmasters. Space exploration falls in this category. Further, it set *example*, something much more vital in a free society than in a driven society. After Roger Bannister ran the first four-minute mile, other runners soon duplicated the feat. A free society needs such outstanding pace setters, in multiple activities, or its standard will be mediocrity. It also needs outstanding organizations. Because of the workmanship examples of the space industry, for instance, the standards for industrial performance have risen throughout the nation. This is especially true in the areas of precision, cleanliness, quality, and reliability. Many organizations have seen what can be done and they are following.

A significant question was recently put to Congress by Representative Jerry L. Pettis, "I ask my colleagues, Mr. Speaker, how many other programs that they have voted for meet the same standards required in the space program? How many other programs have provided stimuli of this significance to our youth and to our country . . .? Certainly it is a program of excellence, setting a high standard for our people and the world."

The Zero-Defects Society

There has also resulted an awareness of the recurring high performance levels which people can ask of themselves. The concept of "zero defects" which was applied throughout the Apollo program demonstrated the capabilities of people to do error-free work. But the space effort didn't start with the capability; it had to be built step by step.

The loss of a screwdriver at Cape Kennedy ten years ago forced a launch cancellation and return of the rocket to the factory for disassembly. There the tool was found. The incident motivated engineer Philip B. Crosby to found an organization to study and help eliminate causes of human error. Called the American Society for Performance Improvement, it concentrated for years on the aerospace industry with the precept "Do it right the first time." The principles learned have since been applied elsewhere and are set forth in the ASPI's *Performance Improvement Handbook*, recently co-authored by 11 men who have

instituted and directed performance improvement programs for their own companies. Commending the publication, Representative Charles Gubser reported that the main thrust of the text is how to go about putting theory into practice "... in a contemporary society that raises its children to consider 30% error acceptable."

Response of the Doctors

Benefits to society abound in the field of medicine. From studies of the astronauts here and in space, some extraordinary new knowledge has been acquired concerning the human organism and its functioning. Most medical research has focused on studies of the sick. The medical research on astronauts has provided an extensive and detailed body of knowledge on subjects in superb health. This program has been a forcing function in the study of the human organism. New medical knowledge has emerged in various areas including hypothermia, cell evolution, circulatory physiology, metabolism, body rhythms, environmental effects and stress, medical instrumentation and education, data collection and information systems, and hospital planning and design.

Hundreds of space-based materials, methods, ideas, and apparatus have emerged for use in the health care field. Such applications are not occurring at random. Special groups are under contract to NASA to actively seek answers to medical problems. Dr. Carl G. Baker, Director of the National Cancer Institute recently wrote: "I want to express my deep appreciation for the support of NASA's Bio-Medical Applications Teams."[50] One problem said, "It would be desirable to have a frozen storage 'bank' of white blood cells for leukemia patients, but white cells are destroyed by existing freezing procedures since the rate of temperature change is not constant (a cooling rate plateau occurs due to latent heat release at the freezing point)." Engineers at the NASA-Goddard center took this problem and achieved the constant freezing rate needed.

For an excellent summary of the advances in space-related medical research, consult *"Space Age Research and Medicine"* by the E. R. Squibb Co. (See Reference 48.)

Fireflies at Johns Hopkins

NASA's latest contribution to medicine was announced recently, a device for detecting bacterial infection in urine

Figure 14. NASA researchers examine the readout paper from a new bacteria detector that is hundreds of times faster than the standard culture technique.

samples (Fig. 14). It takes only several minutes, versus the standard and less reliable culture growth technique that requires up to four days. The device uses a substance (luciferase) from the tail of the firefly. When this chemical contacts any living organism, it flashes. Photoelectric devices measure the minute bursts of light created when this substance is contacted by infectious bacteria. Urinary tract infections are associated with maladies such as kidney/bladder disease and diabetes. This makes the examination of urine one of the most important and frequently done tests in the clinical laboratory today. The Johns Hopkins Hospital, co-developer of the device, sees it as the first practical application of automation in the field of bacteriology. It resulted from NASA research into ways of detecting life on other planets.

Hammocks, Hearts and Hips

Because of such developments, a basic idea of immense benefit to society is catching on in medical circles: the value of utilizing space-oriented companies to solve medical engineering problems. For example, Baylor University's Medical School gave the Grumman Aerospace Corporation team at Houston this problem: develop a means to transport a donor's live heart and lungs to a distant patient who cannot be moved. Grumman developed a nylon hammock to suspend lungs and heart within a chamber, and a spray fog ring to maintain the required 100 percent humidity. Previously, the organs had been immersed in a saline solution and had become "waterlogged."

Implantable heart pacemakers of a unique design have been developed by the Applied Physics Laboratory in conjunction with the Johns Hopkins Medical Institutions. Existing pacemakers are four times as large and require replacement at about 20 month intervals due to battery exhaustion. The new pacemaker will not require the risk or cost of repeated surgical entries because it can be recharged by magnetic induction through human skin. Its miniature electronics and rechargeable nickel-cadmium batteries were originally produced by the Laboratory for use in spacecraft (Fig. 15).

In another instance, the Moore and Hanks Co. of California markets an operating room developed for the Hollywood Presbyterian Hospital, with super sterile conditions never before achieved. They used the environmental controls and the laminar air flow techniques they had developed for the "clean rooms" in which NASA spacecraft are assembled. Surgeons are now safely performing artificial hip joint installations in rheumatic arthritis victims, an operation in which large incisions must remain open for several hours. Formerly, thousands of such cripples had little hope of finding a surgeon willing to perform this operation because of its unacceptably high rate of infection.[51]

Bleeding in Alaska

A promising area for improving health services for the public lies in the use of satellites for communicating medical information. NASA has received proposals for experiments in this field, and tests are underway. Even in the test phase lives are being saved. On Oct. 1, 1971, two women were dying in distant villages of Alaska, one due to appendicitis and the other to hemorrhaging. In a striking demonstration of the value of *static-free* satellite

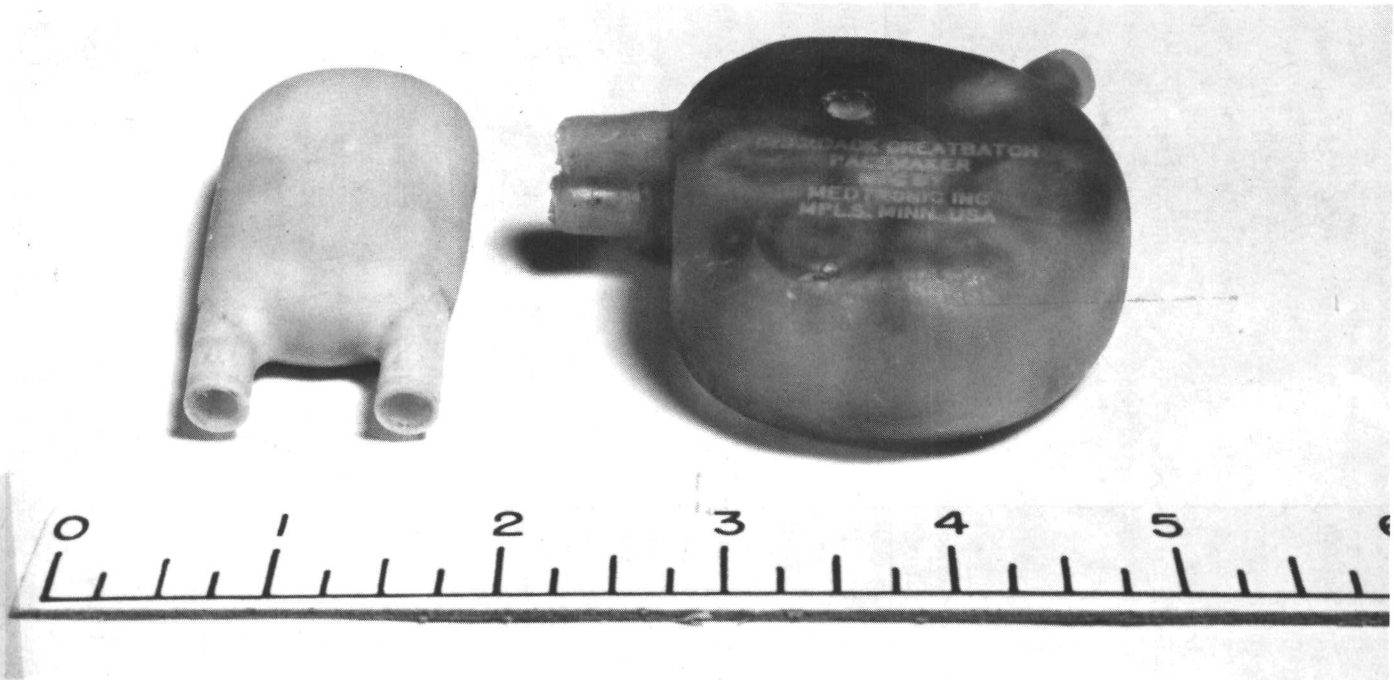

Figure 15. The rechargeable, implantable heart pacemaker is about 1/4 the volume of the standard depletable battery type. Reduced bulk eases the problem of surgical implantation, especially in small children.

communications, doctors transmitted emergency instructions via the ATS-1. This satellite, orbiting at 22,300 miles, south of Hawaii, provides medical communications to 26 Alaskan villages in a test program by NASA and the National Institutes of Health.

Some spokesmen see the need for a medical services satellite in synchronous orbit. Others believe that channels can be rented from commercial satellites and used to carry medical and public health information. Either way, an isolated or remote community using its own antenna could draw upon the facilities, experience, and skills existing at a distant medical center.

Backwoods Radiologists

Medical satellite communications could include live color TV, radio conversations, electrocardiogram and facsimile transmission, interrogation of computerized medical libraries, and teletype-to-teletype transmissions. Medical education programs for health personnel at the remote locations could become standard practice. The consultative service of specialists would be available. Diagnostic assistance or vital instructions in emergencies would be vastly improved.

One radiologist reports that in the rural areas of his state there are no medical personnel with the skill for interpreting X-rays. Consequently, the photos have to be shipped to a distant medical center where there are trained radiologists. Meanwhile, critical hours or days are passing for the patient. In the manpower-short field of radiology alone, prompt transmission of X-ray and fluoroscopic pictures via satellite would vastly improve medical services.

In a January 1972 press release, the Duke University Medical Center announced a 50,000 mile transmission of fluoroscopic examination video tapes through NASA's satellite ATS-1 with the received pictures of the same quality as those transmitted. Doctors said, however, that more research is required before acceptable X-ray pictures can be so transmitted.

Orbits and the Surgeon General

The Surgeon General's office in the U. S. Public Health Service is helping in the planning of future photographic observation satellites. What possible interest could the Surgeon General have in data relayed from a satellite 500 miles out in space? The answer is malaria. "Malaria is still a vicious scourge in many places. Malarial outbreaks tend to occur in the vicinity of newly

cleared land, and new clearings show up conspicuously in pictures taken at high altitude."[52]

The Coming Way to Reduce?

On the Reader's Digest's 50th anniversary, Time magazine waggishly commented on the unrelenting optimism of the Digest's articles and indicated that there should be no surprise to someday find one entitled "New Hope for the Dead." Not quite that extreme is a possibility emerging from NASA research that may provide "new hope for the obese." It developed from experiments in which chickens, quail, mice, rats and rabbits lived on a centrifuge for over six months at two to five times normal gravity. These animals ate twice as much of the same diet as a control group living at normal gravity, or one "g." Yet they did not fatten. The chickens, for instance, had behaved in a very logical manner and had activated a mechanism to reduce the load their legs had to hold up under the increased gravity. The chickens remained perfectly healthy (Fig. 16).

The apparent cause of the weight reduction is a substance whose production is defensively increased by increased "g" force. It is a hormone-like substance, protein-like in nature, produced by the pituitary gland and hypothalamus. This secretion is similar to that found in the human disease known as lipodystrophy and has "fat mobilizing" properties which allowed the animals' fat to be utilized for energy purposes rather than to become stored in body tissues. When this substance was administered to other animals at one "g," they lost body fat.

Experiments with this substance are continuing at the University of California at Davis. The optimists are hoping that it will prove out in rigorous testing to truly be a "fat mobilizing substance" and to have no detrimental side effects. Then, if it can be synthesized for production in commercial quantities, it might become for obsesity what insulin became for diabetes. This is speculation at present, but we do have a promising clue in the research effort to control fat production in humans.

Time for Inventory

Now, consider resources. While we are the crew of this big spacecraft called Earth, it is apparent that someone else put the supplies aboard; and He has hidden some of them rather well. NASA has launched the first in a series of satellites to help find some of the earth's scarce resources and to help manage the use

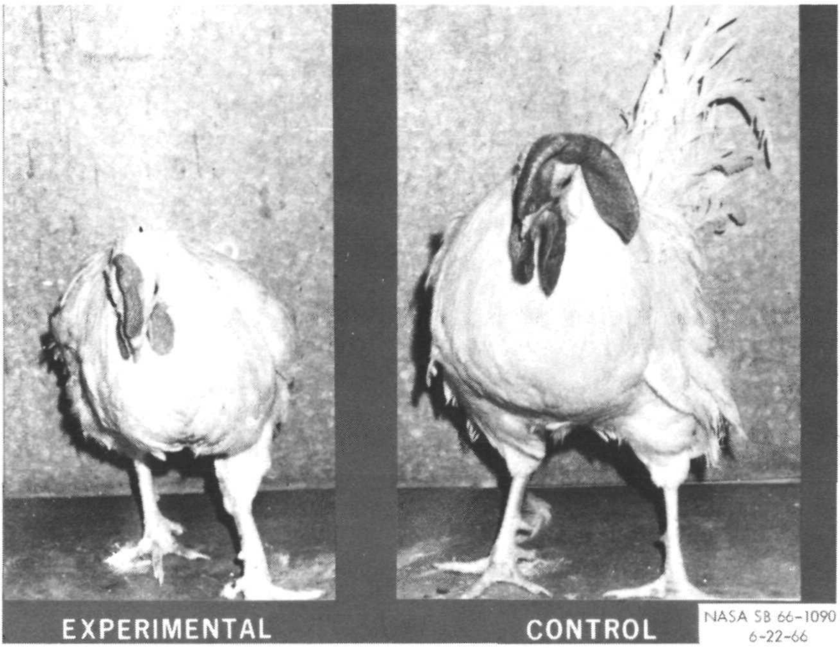

Figure 16. Healthy chickens of the same age raised on the same diet. The experimental chicken was centrifuged for 200 days at gravity levels of 2 "g" or higher. This stimulated secretion of a "fat mobilizing substance" which allowed body fat to be consumed for energy purposes rather than accumulated in tissues.

of certain others. The early spacecraft, called ERTS (Earth Resources Technology Satellites) are intended only for testing equipment and methods.

More than 700 experiment proposals for the analysis of ERTS data were received by NASA from the U. S. and foreign countries. The data's potential value is recognized world wide and scientists of 40 countries are participating in experiments. The New York Times on 2/23/73 quoted scientists about the ERTS-1 (launched the prior July) as "a success beyond our wildest dreams." Canada has become the first foreign nation to install its own station for obtaining data directly from ERTS in orbit. Over $500,000 of special equipment was purchased from RCA and installed at the antenna site in Prince Albert, Saskatchewan, and at the Canadian Centre for Remote Sensing in Ottawa. A similar station is being installed in Brazil.

A recent Wall Street Journal article said, "The value of ERTS-type information was demonstrated by the Apollo 9

astronauts, who photographed Taiwan's southern peninsula in color. The waters to the west of the peninsula have been a fishing ground since ancestral times. But the waters to the east are turbulent and largely unexplored. The Apollo 9 photograph showed that there could be as many fish in the eastern area as in the western. A research expedition later found this to be the case. 'This one photograph of Taiwan could double that nation's fish yield,' says Dr. Robert E. Stevenson, a Government biologist."[53]

But Why Satellites?

Some ask, "Why not simply fly appropriate sensors in airplanes?" William A. Fischer of the United States Geological Survey estimates "it would take 20 years for aircraft to assemble as much data as could be acquired by a single robot satellite in the 18 days the robot would take to completely survey the Earth from pole to pole."[54] In addition the satellite data would be up-to-date.

However, the potential is so great that some smaller scale inventories of natural resources are already being done by airplane. Algeria is being so surveyed by Litton Industries with (1) sensors seeking radiation from thorium, potassium and uranium, and (2) magnetometers sensing variations in the magnetic field due to subsurface geology differences sometimes indicative of oil, gas, or water deposits.[55]

Data at Sioux Falls

The Wall Street Journal further reported that by 1975 the operational satellites, to be called EROS (Earth Resources Observational Satellites), will have followed ERTS and should be flying. The Department of the Interior has contracted $4.8 million for construction of an earth resources data center at Sioux Falls, South Dakota, to process information from these satellites.

"The EROS program plans eventually to inventory the globe's resources with a hitherto unattainable efficiency. Among other things, it would show the health of crops, the sources and extent of pollution, the existence of forest fires, the location of icebergs, and where commercial fish may be. It could indicate unsafe locations for new cities, the possible locations of oil and mineral deposits, and sources of fresh water near the surface. The sensors EROS will carry can penetrate various thicknesses of vegetation, snow, soil, or cloud cover to gather information."[56]

Here is the "Forcing Function" at work again (see p. 11). These initial surveys of earth resources are, in the words of NASA Administrator Dr. James C. Fletcher, the "... beginning of a whole new industry in aircraft and satellite operations, data processing, sensor development and so on ..."

The Ground Truth Requirement

"Establishing 'ground truth' information is an indispensable facet of the ERTS system.* For instance, each variety of fish gives off a distinctive oil slick by which it can be identified. But this 'signature' must be established by direct examination of the object before it can be programmed into the system and used productively."[57] Recognition of a "signature" will vary with the time of day, the season, the amount of shadow, the stage of growth, wind movement of crops, and the angle of observation. But once the identification is made, the signature can be accurately picked out of a multitude of other signatures automatically for computer recording and processing into interpretive displays.

Sensor development is continuing in aircraft overflights of known territory. Recent flights with infrared film produced photographs which distinguished between fields of lettuce, oats, carrots, onions, peppers, and other crops.[58] Airborne sensors can also detect fresh water sources (Figs. 17a, b). Precious fresh water has been found seeping into the ocean from the Hawaiian Islands and from our continental shelf.

The Price of Meat

The Washington Post of April 2, 1972, said, "Very few housewives noticed 18 months ago when helminthosporium maydis – southern corn leaf blight – struck the American farm. They are noticing now. For that attack of corn leaf blight is probably the single most important fact explaining the recent surge in food, especially meat, prices. The increases have badly scarred the administration's wage-price control policy." In the year of the blight, 1970, about 15% of the U. S. corn crop, some 710 million bushels, was destroyed. The price farmers had to pay for feed increased and was eventually passed to the consumer.

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*For the process of applying ERTS-1 data to farming, see Appendix O.

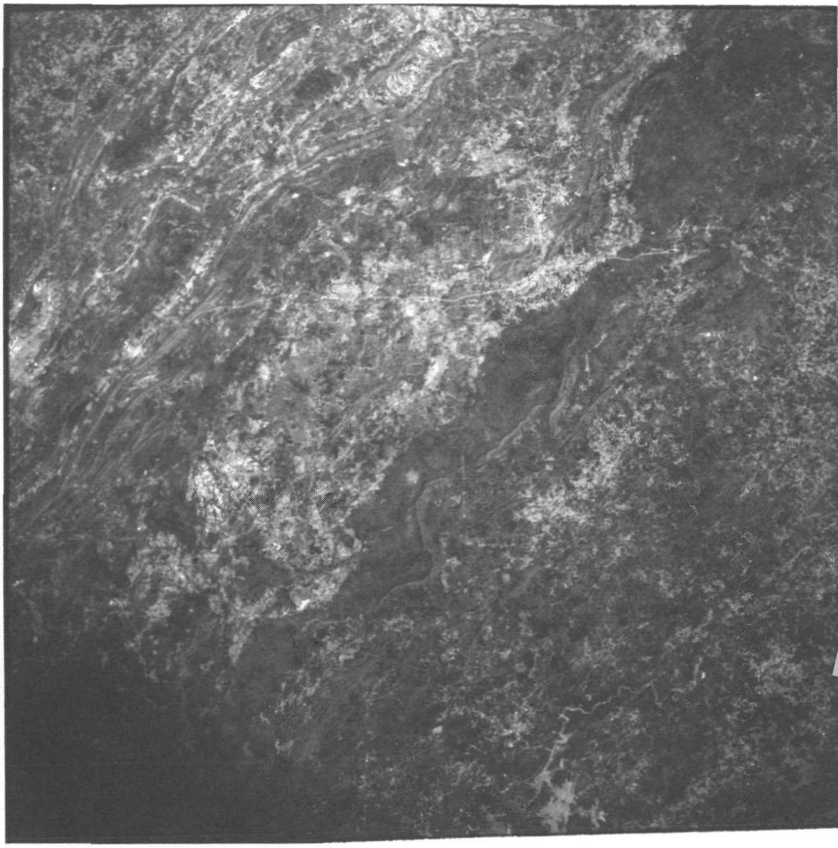

Figure 17a. Photo from Apollo 9 showing area east of Birmingham, Alabama.

Earlier detection to allow control of blight in corn and other crops appears feasible. The Department of Agriculture reports, "Scientists have begun learning to detect from the sky plant disease, insect infestation, and drought before a man on the ground can detect them." The General Electric Co., working on ERTS-type sensors believes, "Satellites could monitor crop conditions and help predict diseases and droughts and even soil conditions to aid in preventing the spread of blights." Hard evidence for these prospects emerged from the joint research of NASA, Purdue University, and the Indiana Agricultural Experiment Station: "Results indicated that the disease was detectable

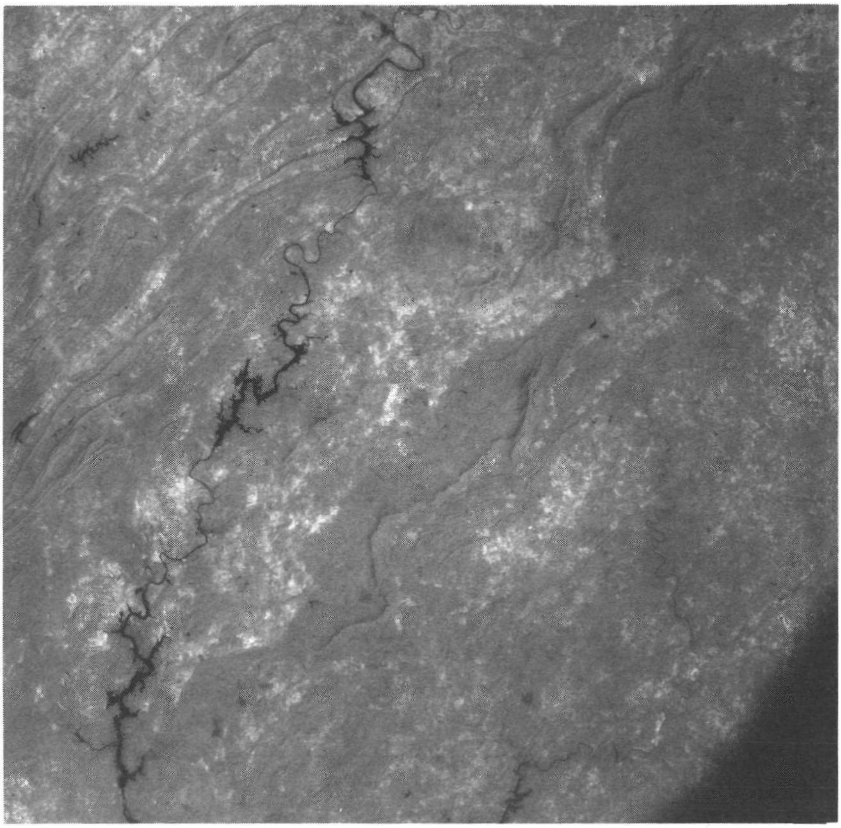

Figure 17b. Photo of same area taken at the same time with an infrared filter and film. Because water shows up black on infrared film, a very sharp contrast of the waterways with the surrounding vegetation and terrain results. This film technique has been used in the problem of dam weakening to find suspected leakage points.

from aircraft at altitudes ranging from a few thousand feet to about 60,000 feet, using advanced remote sensing technology."[59]

Underdeveloped AND Underinformed?

Questions regarding the dissemination of such economically valuable data need to be faced. It will soon be technically possible for an advanced nation to obtain more information about its underdeveloped neighbors' resources than they know,

thus acquiring potential economic advantages.* President Nixon has told the United Nations General Assembly that as the EROS program "proceeds and fulfills its promise," it would be dedicated "to produce information not only for the United States, but also for the world community." Training programs in aircraft-based sensing programs were offered to member nations on the model of the NASA-Brazil and NASA-Mexico "ground truth" cooperative flight projects. Three months later (December 16, 1969) the General Assembly adopted a resolution entitled "International Cooperation in the Peaceful Uses of Outer Space" inviting "...member States with experience in the field of remote Earth-resources surveying to make such experience available to other member states which do not have such experience..."

Where Poppies Grow and Locusts Go

The International Narcotic Control Board has been unable to obtain accurate information on the number and specific location of opium producing poppy fields. Congressman Louis Frey regards this as "one of the greatest weaknesses in present narcotic enforcement efforts." NASA is investigating with the Department of Justice the remote sensing of drug-producing plants. Mr. Frey reports: "It is believed that poppy fields as small as 10 acres can be detected from ERTS-type satellites. Poppies cannot be concealed; they must grow in direct sunlight."[60,61] Such detection plus cooperation between nations could produce worldwide elimination of illicit production of this scourge.

One accepted experiment came from researcher D. E. Pedgley of the Anti-Locust Research Center in London, for detecting from ERTS data the potential locust breeding sites of southwest Saudi Arabia.

Forward into the Past

An archeological experiment was among the 700 proposals NASA received for the ERTS satellites. The proposer, Dr. John P. Cook of the University of Alaska believes that certain instruments in orbit may detect the locations of vanished communities. He reasons that over generations of use these areas become layered with materials which make them observably

*For U. N. debate on this issue, see Appendix P.

different from the original territory. The accretion of imported material and community waste eventually changes the chemical properties of the village soil. It becomes distinguishable from its surroundings when viewed by multi-spectral scanning instruments.

Elmer Harp, Jr., of the Department of Anthropology, Dartmouth College, believes of such remote sensing imagery that "Ultimately, I suggest, we may penetrate to the stage of aboriginal preliterate societies, perhaps even to pre-historic levels of Paleolithic culture."[62] By this means we may gain more knowledge of past civilizations, perhaps including societies previously unknown.

The Flyby Interrogator

ERTS is successfully pioneering another concept of great potential. Numerous data-collection platforms equipped with temperature, humidity, wind-speed and other instruments have been set up throughout the U. S. and its coastal waters. Data is radioed up to ERTS, which then beams it to central receiving sites on the ground for use by meteorologists. Sensors located in streams and rivers beam data to ERTS, providing advance warning of floods.

Dr. Wernher Von Braun wrote recently: "Many additional uses of the ground-to-ERTS data-collection system have been suggested. One example: Tiltmeters – a type of precision level gauge – could be installed in the craters of some 220 active or dormant volcanoes. Since volcanic eruptions are invariably preceded by a volcano's subterranean 'magma chamber' filling up, a passing satellite could relay changes in tiltmeter readings to a ground computer; endangered regions could then be alerted."[63]

Nature and Other Polluters

Nature has done a lot of polluting on her own. The volcanic eruption of Krakatoa in 1889 and of Katmai in 1918 caused variations in upper atmosphere turbidity with global impact on many biological processes (Appendix Q). This naturally-produced contamination eventually subsides. One difference with man-made pollution is that it does not subside; it is continuous and increasing. The significant chilling of the globe since 1950 cannot be accounted for except by the accompanying sharp increase in the concentration of fine particles in the upper atmosphere in the same period.[64] Another difference is that the man-made pollution forces are controllable. However,

control can succeed only after identification of the polluting source and constant monitoring of that source. The problem is global and the monitoring technique will have to be global. Satellite sensing thus offers great promise for the detection of polluters. Without detection and control capabilities the environmental degradation will continue, for as the famous Pogo of the comic strip so accurately observed, "We have met the enemy and they are us."

See You In Court

Specialized instrumentation is already being used (New York Harbor) in airplane tests to trace pollutants. NASA researchers have developed radiometers for detecting and determining the size of oil slicks, and distinguishing between light and heavy oils. This can help to identify the polluter. In a recent legal dispute, Vermont used images from the ERTS-1 multi-spectral scanner to show that pollutants plume from a paper mill on the New York shore of Lake Champlain.

Radioactive Garbage

The wastes from atomic power plants now in operation are accumulating at an increasing rate. Currently they are being stored underground in metal tanks by the countries utilizing nuclear reactors. Traces of plutonium, with a half life of 24,000 years, remain in the waste. There are proposals to store this waste in abandoned salt mines. Queried on this, the Chairman of the Atomic Energy Commission, Dr. James Schlesinger, said: "In addition to that, we are exploring other methods of disposal, including encouraging NASA to look into the cost of shooting these high-level radioactive wastes into the sun – taking them right out of the world. Now, this would depend on development of the space shuttle (approved by President Nixon on January 5, 1972), and that is a decade away. We hope to remove these wastes permanently from the environment of man."[65] Disposal into interplanetary space, using Jupiter's gravity field as a sling shot, "could result in a cost of one tenth or less of the cost of waste disposal into the sun"[66]

The Longer Arm of the Law

For the protection of society and the rights of a suspect there is need at the time of an arrest for a high-speed verification of any prior criminal history. Courts in many states expect no more than a 4 to 8 hour delay between arrest and initial arraignment hearings. Currently, fingerprints are transmitted to state central files or to the FBI. They normally go by mail

because of the need for accuracy. A seven to ten day period is generally required to obtain a reply. The FBI receives about 30,000 print sets a day.

The ATS-1 satellite was recently used in a finger print transmission test funded by the Law Enforcement Assistance Administration (LEAA). Conducted by the State of California, for a consortium of 20 states seeking to apply technology for the improvement of law enforcement, the experiment sent prints from Los Angeles through the synchronous satellite to central files in Sacramento. They were verified within minutes. Prints included sets from actual suspects and these resulted in "hits" or actual identification (Fig. 18). Paul K. Wormelli, coordinator of the experiment, said in Business Week (Jan. 29, 1972): "Transmission of fingerprints with land lines would be very expensive. A dedicated satellite might cost as little as $15 million. We could probably pay for it with the money saved in LEAA's travel budget."

Some officials express a need for satellite facilities shared on a national basis for many functions in law enforcement including data, video (conferences, training, coordination, etc.), and voice communications (particularly useful in disaster control), as well as document transmission. It is significant that "a computer interface link is already carried by satellite between the Honolulu police system and the California Highway Patrol. . ."[67]

Food and Disaster

The precautions taken with food for the astronauts have led to new and improved methods of processing, preserving and sterilizing edibles. Dr. Werhner von Braun summarized the need and some effects as follows: "It now seems that the food industry, facing increasing problems in the use of food additives and nutritional quality, may be able to draw on NASA's extensive knowledge about food processing, preservation, and nutritional value. We have extremely rigid requirements for the food we supply the astronauts since any type of food system failure would have grave consequences. Food must be free from bacterial contamination; it must be of high, known nutritional value; it must be stable without refrigeration under wide temperature variation for long periods of time; and it must be capable of fast, reliable and fool-proof preparation.

"Using NASA-developed methods, certain foods can be prepared and stored for emergency situations. If a disaster

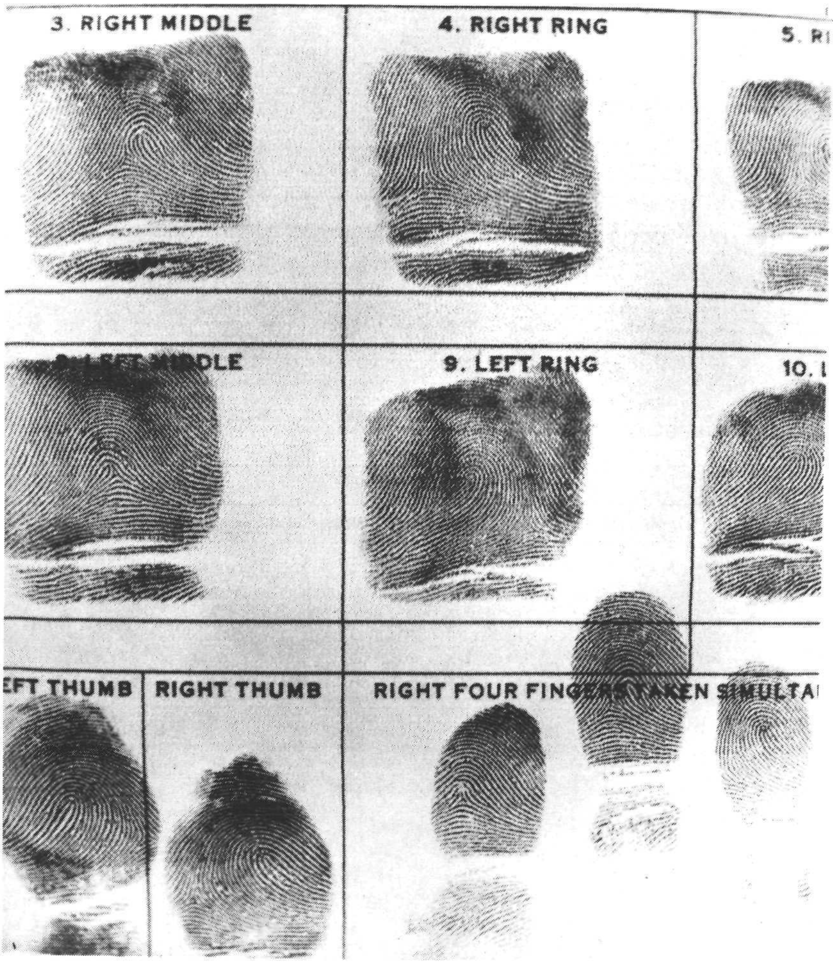

Figure 18. Fingerprints as received after transmission through the synchronous orbit satellite ATS-1 by the California Crime Technological Research Foundation.

occurred, the food could be immediately shipped to the stricken area with no loss in preparation time and no need for refrigeration." A report titled "Food Technology" describes NASA's research in the effects of processing, preserving and additives on the nutritive value of foods.[68]

Burros, Sensors and "Host Rocks"

There is a scientific basis for the optimism about the use of satellites in prospecting for minerals. In a recent article in

Foreign Affairs, these thoughts were expressed by Dr. Robert Jastrow and Dr. Homer E. Newell:[69] "The prospector and his burro are essential in the search for mineral deposits, but aircraft play an important supporting role, and so should satellite reconnaissance in years to come. In some cases geological faults – cracks in the earth's crust which are likely to be associated with ore deposits – can be seen in photographs taken from orbit. In other cases the presence of a buried ore deposit is signaled by a particular type of rock on the surface. Experience shows that an ore deposit is often surrounded by a special kind of rock, known as the 'host rock' for that type of ore. Since different kinds of rock reflect sunlight in different ways, wide-area photographs of the region taken from a satellite can reveal the telltale host rock that indicates an ore deposit.

"The stakes are high in this game. One estimate places the yield from potential satellite discoveries of mineral deposits in the United States at $2 billion a year in royalties alone. The total value of mineral deposits discovered each year by ordinary prospecting on the ground in the United States, Canada, and Mexico amounts to roughly $10 billion. It is possible that several times this sum could be the global yield from major improvements in mineral prospecting. Here we reach the neighborhood of tens of billions of dollars in direct economic benefits from a single application of satellites. These gains would dwarf the investment in the underlying space technology.

"Mining activities in northern Canada illustrate the economics of satellite prospecting versus ground prospecting. A single rock outcropping near Kitt Creek in Ontario led to the discovery of the famous Timmons deposit, one of the world's largest bodies of copper, zinc, gold and silver. This single find is estimated to have a value in the neighborhood of $10 billion. The find was made by a lucky fluke when a prospector stumbled across a small outcrop of ore that gave him a clue to the massive treasure-lode lying beneath the surface.

Geologists believe that many deposits as rich as the Timmons find may exist in the area because it belongs to one of a number of belts of green schist – a type of rock deposit frequently associated with rich ore. The total area of the belts in this region is roughly 100,000 square miles. The terrain is too rough for jeeps or burros. Recovery of its mineral wealth requires systematic exploration of the entire region on foot, by prospectors stopping every hundred yards to collect soil samples for laboratory analysis. Tens of millions of dollars would be required to complete a survey of this one region. A complete exploration on foot is a workable

approach in principle, but forbidding in practice because of the prohibitive cost."

Minerals in the Tree Tops

"The same analysis applies *a fortiori* to the still more difficult terrains of Brazil, equatorial Africa and Southeast Asia, in which a heavy cover of trees and vegetation makes ground exploration exceedingly difficult and expensive. The available evidence suggests the presence of large deposits of mineral wealth in these regions. Again it seems incredible that a satellite hurtling through space hundreds of miles above the surface of the earth should be able to detect mineral deposits concealed by a heavy tree-cover. But an example will indicate how this might work. Research has shown that trees growing in metal-rich soil absorb the metallic elements of the soil into the structure of their cells. As a consequence, the tree leaves reflect sunlight differently from leaves on the same type of tree growing nearby in ordinary, metal-poor soil. The rest of the story is clear: Measure the intensity of reflected sunlight over a continental expanse of forested regions by means of instruments mounted in a satellite, and look for the critical patterns that betray the presence of mineral deposits.

"As a test of this method, measurements have been made at tree-top level at a site near Cooper Creek, Arizona. They show large differences in the reflected sunlight from two neighboring trees, one located in soil with a high abundance of copper and molybdenum, and the other growing nearby in ordinary soil. The tree growing in the metal-rich soil reflects twice as much yellow light as the tree growing in ordinary soil, but half as much blue light. This combination is an unmistakable sign of the presence of the metals. Such measurements obtained from a satellite can be used to guide the prospector to the mineral wealth of millions of square miles, with a great saving in time and money."*

Factories Aloft

Also of great potential for society are the products which can come from manufacturing in space. General Electric Co. foresees the fabrication of crystals up to 6" in diameter in zero gravity. On earth they can't exceed 1½". They could find use as

*For other evidence of satellite utilization in prospecting, see Appendix R.

very large power transistors, or, if made of pure quartz, as optical blanks for lenses of near perfect quality. These large, homogeneous and pure crystals are prime candidates for commercial space manufacturing even at today's cost of space transportation.

It is expected, without gravity's stratification effects, to produce a foamed steel having the weight of balsa wood, but many of the properties of solid steel. Also possible are metals of a purity not attainable on earth.[70]

The levitation-melting technique is expected to produce alloys and composites with maximum intermixing of constituents, minimum contamination, and previously unachievable uniformity. On Earth, the desired embedded fibers or particles either float or settle, but in space this should not occur. Materials of superior characteristics are expected to be formed. Extensive work in these experimental areas will be done in the manned Skylab missions.

Electrophoresis Sans Gravity

The first zero gravity experiments in materials processing were conducted on Apollo 14. One employed the principle of electrophoresis which utilizes an electric field to cause directed migration of organic molecules having an electric charge in an acid or alkaline solution. With gravity's influence removed, the electrophoresis technique can separate different molecules to prepare organic materials of uniquely high quality for valuable roles in medicine and biological research (Appendix S).

Some pharmaceutical firms are working on vaccines for viruses that sicken or kill humans. One process consists of breaking the virus and extracting the protein of its skin to develop the vaccine. Unfortunately, the genetic material inside the virus frequently causes tumors in mice. For a human vaccine this material would have to be completely removed. The best foreseeable centrifuges will apparently not be able to do the job. Pharmacologists believe that electrophoresis processes in zero gravity aboard spacecraft *might* do it and produce a great boon for mankind.

Other scientists wish to use space electrophoresis to separate blood cells. Immunologists believe there is more than one class of lymphocytes, or white bood cells. One apparently resists viral infections. The other resists bacteria and the presence in the human body of foreign matter (such as a kidney transplant). At present, only space electrophoresis holds promise of being

able to provide the purity and quantity needed for clinical use. Success could allow removing from the patient's blood those lymphocytes which reject transplants while leaving in the type which resist infection.

Prophets of Profits

Almost totally unknown to the American public are the very serious ideas coming from industry for generating a profit from manufacturing operations conducted in space. With pun recognized, these operations could be the highest of the high-technology activities of American industry. If pilot plant operations bear out the promise, the products manufactured could not be duplicated by any non-space nation. Our balance of trade could be favorable for decades. The volume of business potential is described by Mr. Daniel J. Fink, a vice president of General Electric Company: "It has been estimated that by the end of this century the total value of electronic materials and biologicals manufactured in space could run upward of $15 billion."

This estimate is supported by the following table from "Manufacturing in Space – Payloads for the Space Shuttle" by L. R. McCreight and Dr. R. N. Griffin.[71] Conservatively, it omits any estimate of markets for new metals, composites of materials, and the new class of highly refractive glass which would allow significant size reductions with equivalent optics performance.

NASA's planning for research in space manufacturing includes experiments to be flown on the Skylab spacecraft and in

Table I. Predicted Space Manufacturing (Electronic Materials and Biologicals) in 2000 A.D.

Product	Product Quantity/ Year (Tons)	$/Pound	Product Value ($Millions)	Shuttle Flights/ Year at 25,000 Pounds/Load
Electronic Materials				
• Float Zone Refined Semi-Conductors	70 to 250+	450	60 to 225	6 to 20
• Oxide Crystals	10 to 50	1,000	16 to 100	1 to 4
Biologicals				
• Vaccines	1	100K to 1 M	12000 to 15000	10
• Blood Cells	10	1,000	20	10

"sortie labs" placeable in the payload bay of the Space Shuttle (Fig. 19). It is hoped that this development work will lead to pilot-plant manufacturing operations in permanently orbiting space stations, with some full-scale commercial manufacturing status for urgently needed items in the 1980's. By the turn of the century space manufacturing may account for a significant fraction of all space operations and be an essential function in the world's economic activity.[72]

Who Owns the Sky?

Professor James Allen of the University of Colorado believes that space exploration will compel creation of a new legal and judicial process and approach to the problems of international law. The United Nations is hard at work on this problem. Allen asks, "How far does national sovereignty extend beyond the narrow band of atmosphere?" Such questions cause him to say "I maintain that the principal challenges of space lie in the broad field of government and society. It is there that its

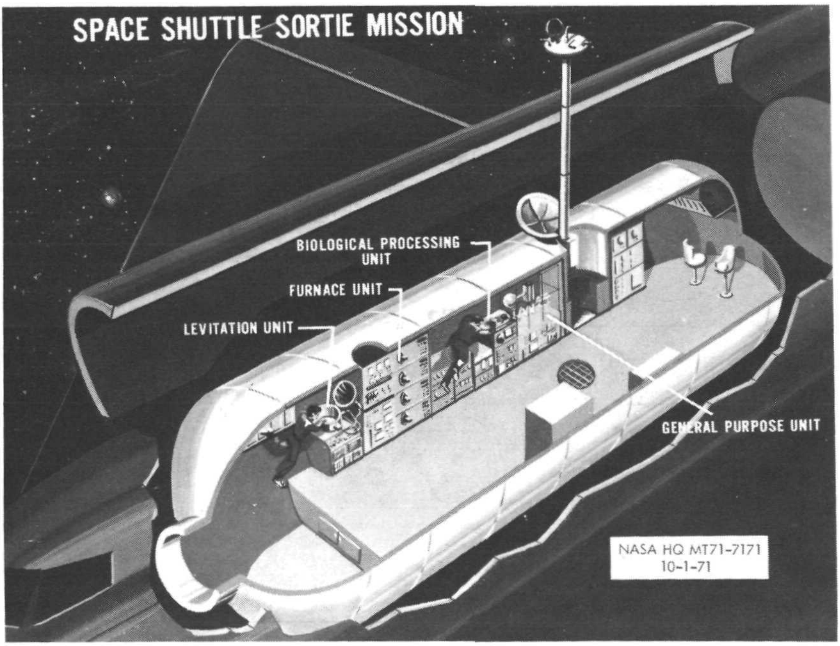

Figure 19. Artist's concept of a "sortie lab" to be carried in the cargo bay of the Space Shuttle. Modular units like this will serve as laboratories for experimental work in materials science and manufacturing in space.

effects will be felt, as have all technical progress of the historical past."

Domestically, he is already right, for the executive and legislative arms of government are now grappling with solid problems from the vacuum of space. One area alone, communications satellites, has been the subject of Presidential policy pronouncements, Congressional filibusters, and policy participation by the Departments of State, Defense, and Justice; the Federal Communications Commission (FCC); and the New York Stock Exchange. The FCC is beset by a flood of issues stemming from the desire of TV broadcasting companies to orbit their own satellites for private carriage of programs. Included are questions of monopoly, rate setting, frequency allocation, and interpretations of the meaning of the policy phrase "in the public interest, convenience and necessity."

Canada's Equatorial Resource

Apparently no nation is going to "own" the sky, but some seek to beat potential rivals to utilization of choice locations. Canada's "Chapman Report" of 1967 recommended to the Prime Minister that Canada take immediate steps to claim an 18,000 mile long equatorial band at 22,300 miles orbit (between 75°W and 115°W longitude). It feared that some other nation would station a synchronous satellite there and that the "territory" would be "lost forever" to Canada's need for a domestic communications satellite system. The report continued: "This territory should be treated as prudently as Canada's water resources. It should be shared, rented or sold only on terms that are good for Canada."[73] Ironically, Canada's operating system now leases circuits to subscribers in the U. S.

The Law of the Void

A Soviet Draft Declaration for a U. N. resolution declared "Sovereignty over outer space or celestial bodies cannot be acquired by use or occupation or in any other way." The Canadian recommendation for preemptive use of a space area is only one of a growing number of space related issues society must cope with...hopefully by agreement, regulations or international law.

The subject is primarily the province of the United Nations, where a body of Space Law is being developed.[74] It is not merely an extension of aviation law, although some acts have already begun to fall under existing rules. For instance, the

International Telecommunications Union has added to its jurisdiction problems of interference with space communications.

The nature of the space business makes some types of accidents conceivable and credible. A few primary areas of liability appear to be: falling boosters, spacecraft and debris; collisions of spacecraft or of spacecraft with aircraft; interference with communications; provision of erroneous navigational information; and nuclear and biological or other pollution. Rapidly developing technology makes it imprudent to attempt an exhaustive list.

To cover some of the areas of liability, the U.N. has concluded a treaty called the Convention on International Liability for Damage Caused by Space Objects. There is no dollar limit on claims. It covers aircraft in flight or objects on earth which are damaged by objects falling from space; it also covers damage one spacecraft may do to another in space. At present the U.N. treaties and resolutions are self-policed, self-denying approaches to conflicts on such issues and ownership or control of space resources.

The legal framework includes: numerous U.N. resolutions: the 1967 General Treaty of Principles on the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies; a treaty banning nuclear weapons tests in space; an agreement regarding commercial communications satellite systems; and an agreement on the rescue and return of astronauts plus the return of objects launched into outer space. Most of the U.N. work is the responsibility of the Legal Subcommittee of the Committee on Peaceful Uses of Outer Space, created in 1959.

Silent Sentries

The security of society is advanced by certain space activities. Dr. Edward C. Welsh, formerly of the National Space Council, says "... we are using space to increase our alertness to dangers and to lessen the likelihood of aggressive action by others..." Emphasizing the value of observation satellites to national security, Time magazine recently said, "Aside from making telescopic spying and communications eavesdropping more effective, a well-outfitted space lab can easily detect the thermal wake left, for example, by a nuclear submarine."[75] The recent book "Secret Sentries in Space," suggests that satellites have considerably diminished the danger of war through miscalculation by allowing the major thermonuclear powers to examine one another's military installations in exact detail.[76]

The potential influence of observation satellites on conventional warfare is intriguing. General MacArthur's successful amphibious end run recapture of Seoul in the Korean War could probably not proceed in secrecy today. Of more recent vintage is the India-Pakistan war which created the nation of Bangladesh. The aerospace magazines reported that the USSR sent up several "quick look" satellites over a period of days to see what the U. S. 7th Fleet was doing. The intelligence obtained supposedly accounted for a Russian naval force arriving in the Bay of Bengal on the heels of American vessels.

Counting the Tubes

Former Vice President Hubert Humphrey emphasized the reconnaissance satellites' value when he said, . . . "I don't think it's any breach of security to tell you that I have seen pictures of the shipyards in which the Soviet "Polaris" submarines were being built. And the picture was so accurate that we could tell how many tubes the submarines had."[77] Progress since then has yielded an inspection tool for making arms limitations agreements practical.

Dr. Wernher von Braun believes that, because of satellites, "secret military moves by any nation will be almost impossible by the year 2000." To achieve these security benefits, others believe, "We cannot afford to allow the Soviet Union to dominate space. No matter what the treaties say about peaceful use of space they will be useless if there is none to challenge a violator. We do not yet know the extent of the military value of space domination. It could be supremacy over the earth. At present the U. S. alone is capable of seeing that it does not happen."[78]

Drama and Value

The areas of effect on society far exceed what have been considered here. For instance, public participation. It is a fact that hundreds of millions of TV viewers were personally involved in some of the greatest dramas in man's history of exploration, participating as it occurred.

Participation generated personal opinions. A recent tax-oriented letter to a newspaper said, "It cost me $4.97 for Apollo 15, it cost me the same for a recent record album I bought. Which has given me more for my money?"[79] For many, America's manned flight achievements often seemed like the only good news around in the 1960's. For others, manned flight

demonstrated what they called "NASA's stunt man philosophy."

A Profit Grubbing Society?*

Neither have we considered world opinion. An article in the Los Angeles Times said: "Little we have done recently has evoked as much admiration as our achievements in space. It would be unfortunate if curtailing our space objectives strengthened the foreign image that views America as a wholly materialistic, profit grubbing society striving almost exclusively for immediate gain."[80]

And in terms of international influence: Dr. Foy D. Kohler, former U. S. ambassador to Moscow believes that "Soviet influence in the world increased by leaps and bounds after Sputnik and the U. S. was hard put to hold its own." He explained: "A nation's reputation for leadership and technology is regarded as a basic political factor, a basic factor of the power potential of that nation. And other nations that don't have it take note and trim their sails accordingly."

America's National Style

Some observers believe that one element in President Kennedy's lunar landing decision was "... straightforward balance-of-power politics" as an instrument of American foreign policy, and that space competition was "... part of an effort to contain the expansion of Soviet power."[81] Dr. John Logsdon believes that the decision to compete in space technology was "a reflection of the American national style." This style is based on our experience from the Puritans to today of directing American energies at a mastery of nature, not a mastery of people. This is encouraging, for as historian and philosopher Salvador de Madariaga observed, "It is from men who act on nature, and do not merely suffer to be acted upon by her, that history flows."

Dr. Logsdon also believes that the reasons for the lunar landing decision were "political, not military," and consistent with our historical attempts "... to spread our way of life by demonstrating the economic and social success it has produced." Walt Rostow has explained this ideology-export drive as a survival effort, saying "... under modern conditions it is difficult to envisage the survival of a democratic American society as an island in a totalitarian sea."

*For a comment from 370 B.C., see Appendix T.

Society Impacts Space

There was willing funding when Sputnik exposed our technology lag and society feared the implications. However, society has since changed its priorities, and NASA funding is now about half what it was in 1966. Influential spokesmen have singled out space research for attack, balancing the NASA budget against the elimination of poverty. Proponents of space research point out that even total elimination of the entire space budget (which no opponent is proposing) would add only a penny and a fifth to every 47 cents now going to social needs; and they wonder if anyone seriously believes that this would significantly affect the problems of schools, crime, urbanization, pollution, housing, transportation, poverty and hunger.*

Mules at Cape Kennedy

NASA Administrator Dr. Thomas O. Paine participated in a dramatic confrontation on such issues the night before Neil Armstrong's Apollo 11 launch to the moon. At the gates of Cape Kennedy he discussed these complex social problems with the Reverend Ralph Abernathy and the poverty marchers who had arrived with mules and wagons to protest what they called the misapplication of the nation's resources.

Dick Gregory, nationally known comedian and a black activist, saw the situation differently: "I've always felt that we as a nation are rich enough to get to the moon and solve the problem of poverty too. I don't agree with the people who say we should spend the money to go to the moon on poverty instead. We could do both. What happened to poverty before we had a space program? What happened to poverty before we had a Vietnam war?"[82]

NASA has been on the defensive financially since about 1966 as a result of the diverse beliefs concerning national priorities. The situation has led to great debates in Congress which have helped clarify a more basic issue: *the importance of technology to a modern nation.*

Technology and Poverty

In today's world, technology is the scientific tail that wags the social dog. It should be apparent that in the name of humanity as well as enlightened self-interest we must maintain

*See Appendix U.

and promote our national technology. It is not by chance that the most underprivileged, poverty-stricken nations are the very ones whose science and technology are the most backward and primitive. Senator Mike Monroney once expressed the need very well. He said: "Starving our technology mortgages the future of our society. Twenty years ago Britain picked immediate social goals over technical progress. Today it is paying the price, lacking the production base to support either social or technical progress."

Claims and the Money

Several conclusions were recently expressed by the President of the American Institute of Aeronautics and Astronautics, Dr. Karl G. Harr, Jr. He says there is a direct and beneficial relationship between America's space effort and:

(1) the strength and growth of our overall economy;
(2) our standing among the peoples and nations of the world;
(3) our national survival;
(4) our capacity to deal effectively with all national needs.

And what does it cost? The average citizen doesn't know. But he is convinced that it must be extremely high. For some reason society behaves as if the cost of the space effort is proportional to the publicity which it receives. When questioned, even critical audiences (who should be better prepared) usually do not know the space agency's annual budget. A frequent "guesstimate" is 20 billion dollars per year. This version stems from space opponents' continual emphasis on "the cost of going to the moon." This amount was the target price and the achieved price of the 9-year-long lunar landing national goal.

It comes as a shock to many to learn that it would take eight years for NASA's annual budget to add up to one year's payment of interest on the national debt. To bring the issue of expenses into perspective, here are some budget comparisons:[83]

Proposed Fiscal Year 1974 Expenditures	Billions of Dollars	Cents Per Dollar
• Total for the Federal Government	$268.7	100
• National Aeronautics & Space Administration	3.1	1.15

Proposed Fiscal Year 1974 Expenditures	Billions of Dollars	Cents Per Dollar
• Interest on the National Debt	24.7	9.2
• Defense	81.1	30.2
• Human Resources (education & manpower, health, income security, veteran's benefits & services)	125.5	47

Counterbudget

Some far-sighted social planners have come to realize the need for balance in allocating national resources. It is based on the reality that disbursing tax dollars to effect *social* change involves the *redistribution* of *existing* wealth, but spending to effect *technological* change involves the *creation* of *new* wealth. The National Urban Coalition's *"Counterbudget"* states that ". . . without some minimum rate of investment in research, this society will find itself economically noncompetitive in world markets and losing ground in the struggle to keep pace with many public problems."[84]

The situation becomes more urgent as we lose major portions of our markets to foreign competition. It is not merely competition in cameras, watches and radios any more. Our competitors' technology has improved to the point that we are losing markets, jobs and income to them in the production of steel, autos, ships, electronics, heavy machinery and machine tools. Business Week reports "In recent years, U. S. imports of high technology products have been growing 2½ times as fast as our exports of such items."[85]

We all know that the very act of spending federal money has an influence on the economy. It produces at least a *short term* benefit, especially in the region where the money is spent. However, when federal funds have been directed into truly *creative* efforts, there have been far greater *long term* benefits as a result. "Government-sponsored research has, over the years, produced the discoveries that have triggered the development of computers, lasers, atomic power and many others."[86] As one editorialist recently put it, "A nation of dam builders and leaf rakers may have been adequate to stave off economic disaster in the 1930's, but it will not suffice for survival in the 1970's."

Technology and the Black American

Spending to effect *technological* change can also produce direct *social* change. For example, the status of minorities in our society has been impacted by technology through the creation of new industries which spawned new jobs and new professions. The NASA-propelled growth of the computer industry in the 1960's opened up tens of thousands of jobs to black citizens. Peter Drucker points out that 'there is less resistance to the Negro in knowledge jobs than in manual jobs. Knowledge jobs are expanding so much more rapidly that the Negro is less of a competitive threat." He believes this can affect relationships between the races: "Social status is determined at the top of the social ladder. And the knowledge worker, needless to say, is the leading group in the knowledge society. Negro knowledge workers have been increasing at twice the rate of the white knowledge workers." Drucker believes that the growth of knowledge jobs is providing "the greatest opportunity the black man has yet had in America."[87]

Attitudes Toward Technology

There are large numbers of people who can applaud the young medical missionary administering vaccine to a native child, but who have no appreciation for the young chemical engineer working the night shift in the factory producing that vaccine. His skills and his labor and the benefits of his technology are taken for granted. At least this is a neutral attitude. Unfortunately, however, there is growing in America a hostile attitude toward technology. One dramatic evidence of attitude appeared when the men of the Apollo 15 science mission were deploying experiments on the moon. At that time there was on sale in Times Square a life sized photo poster of a fully suited astronaut standing on the moon beside an American flag. The poster had a large caption reading "So What?"

Some anti-technology spokesmen advocate a return to the simpler life of decades ago, while others wish to at least restrain the pace of technology and still others wish to control which technological advances are allowed into practice. Many seek a moratorium on change, at a time when the rate of technological change is accelerating. Some of these people show symptoms of the syndrome which is called "future shock" by author Alvin Toffler. He defines it as "the mass effect of the dizzying disorientation brought on by the premature arrival of the

future."[88] Dr. Wernher von Braun tells the story of the little old lady who was asked if she was ever going to ride in an airplane. She responded, "No siree! I'm just going to stay right here on earth and watch television, like the good Lord intended."

Some spokesmen blame technology for many of the sour products of modern life. But the villain is not technology; it is the mismanagement of technology. Of itself, technology is neutral. Neil Armstrong, first on the moon, expressed it well, "Technology does not improve the quality of life; it improves the quality of things. Improving the quality of life, however, requires the application of wisdom." As Dr. Max Lerner of Brandeis University put it, "You have to use technology to heal the scars left by technology."

We do not need less science and technology; we desperately need more if we sincerely intend to keep this planet livable.

The Chinese Penalty

It has been said, "Good judgment is the result of experience and experience is usually the result of bad judgment." Let us hope that America isn't following that route to learning. The consequences for the nation exercising bad judgment are enormous. Other nations bear scars from their bad judgments. For example,[89]

> "Early in the 15th century, the Chinese had become a formidable maritime power, far ahead of the rest of the world in the sciences and technology of the sea. Their ships ranged from Madagascar and the Arabian Gulf to the East Indies and Korea. Unlike Europeans of the time, the Chinese had learned to sail against the wind and in direct route out of sight of land. Their ships were huge, almost four times as large as the Spanish galleons of three centuries later, and were capable of carrying 2,000 passengers each on months-long voyages. They were in the forefront of a new technology.
>
> "Abruptly, the Chinese government closed the huge shipyards in Canton and other coastal cities and used the money earmarked for maritime development for other purposes 'closer to home.' Young people's interest in the sea waned for lack of inspiration and guidance. Thus came a major turning point at a critical time in Chinese history, for within a century the Portuguese and other Europeans with inferior knowledge of the sea came to the Far East by ship, eventually to humiliate the Celestial Empire. The Chinese still

pay the penalty for abandoning their interest in naval research and education."

President Kennedy's goal to create a "space faring nation" and "sail this new ocean" has been achieved. Will we now, like the Chinese, abandon our preeminence? America should never have to pay a similar penalty.

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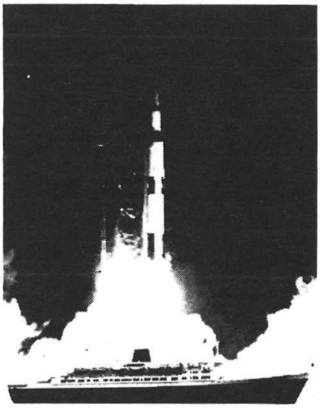
APPENDIX A

THE PUBLIC AND THE LAST APOLLO

A wag once remarked, "Nostalgia isn't what it used to be." Advertisers, however, recently laid some groundwork for its recovery with the ad shown below.*



Special Moon Shot Cruise.
We'll anchor just offshore to see the last moonshot, then cruise on to St.Thomas and San Juan.

SAIL FROM NEW YORK DECEMBER 4 ON THE S.S. STATENDAM. 9 DAYS, $370 TO $875.

It's something to tell your children and grandchildren about. The last scheduled men on the moon, and you were there to see them off this December sixth. First, the suspense of the countdown, the rocket's red glare, then an eye-filling, sky-filling sight to be seen for miles around, yours from a cruiseship anchored just offshore.

And after they shoot the moon, we'll do our best to shoot the works for you. We'll take you to St. Thomas, San Juan. We'll dine you and dance you, romance you with stars, shows, feasts and people who wait on you hand and foot, no gratuities required.

There are cruises and cruises, but there's never been one quite like this before. Ask your travel agent about it, or call us up, or send us the coupon.

Holland America Cruises
Pier 40, North River, N. Y., N. Y. 10014
Tel (212) 620-5101

Please rush me complete details on the Statendam Moon Shot Cruise. Rates, accommodations, everything.

Name________________

Address________________

City__________ State__________ Zip__________

Travel Agent________________

Special Space-Related Symposiums

This special cruise is going to have some special passengers giving some very special symposiums chaired by Captain Edgar Mitchell, Ret., sixth astronaut to walk on the moon. Names like Arthur C. Clarke, Isaac Asimov, Norman Mailer. Geophysicists, aeronautical engineers, astronomers, anthropologists, biochemists. They'll hold seminars on topics ranging from "Apollo and the Moon—Man's First Conscious Step in Evolution", to "The Mythology of other Star Systems—Constellations Unseen by Human Eyes." You'll even have the rare chance to attend a lecture by Dr. F. Drake on "Interstellar Communication" at Arecibo, the 1,000 foot radiotelescope deep in the jungles of Puerto Rico. These seminars and related social functions are an extraordinary feature, and naturally, at an added cost. Cabins for the special moonshot cruise plus the seminars range from $750 to $1400. Details available on request.

On all Holland America Cruises, no gratuities required. Rates per person, based on double occupancy and subject to availability. The s.s. Statendam is registered in the Netherlands.

Society's behavior here has some of the incongruous aspects of the hunter who admires the creature in his sights.

*New York Times, Oct. 8, 1972.

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APPENDIX B

PIONEER 10 PLAQUE

The Pioneer 10 spacecraft carried a pictorial plaque designed to show scientifically educated inhabitants of some other star system – who might intercept it millions of years from now – when Pioneer was launched, from where, and by what kind of beings.

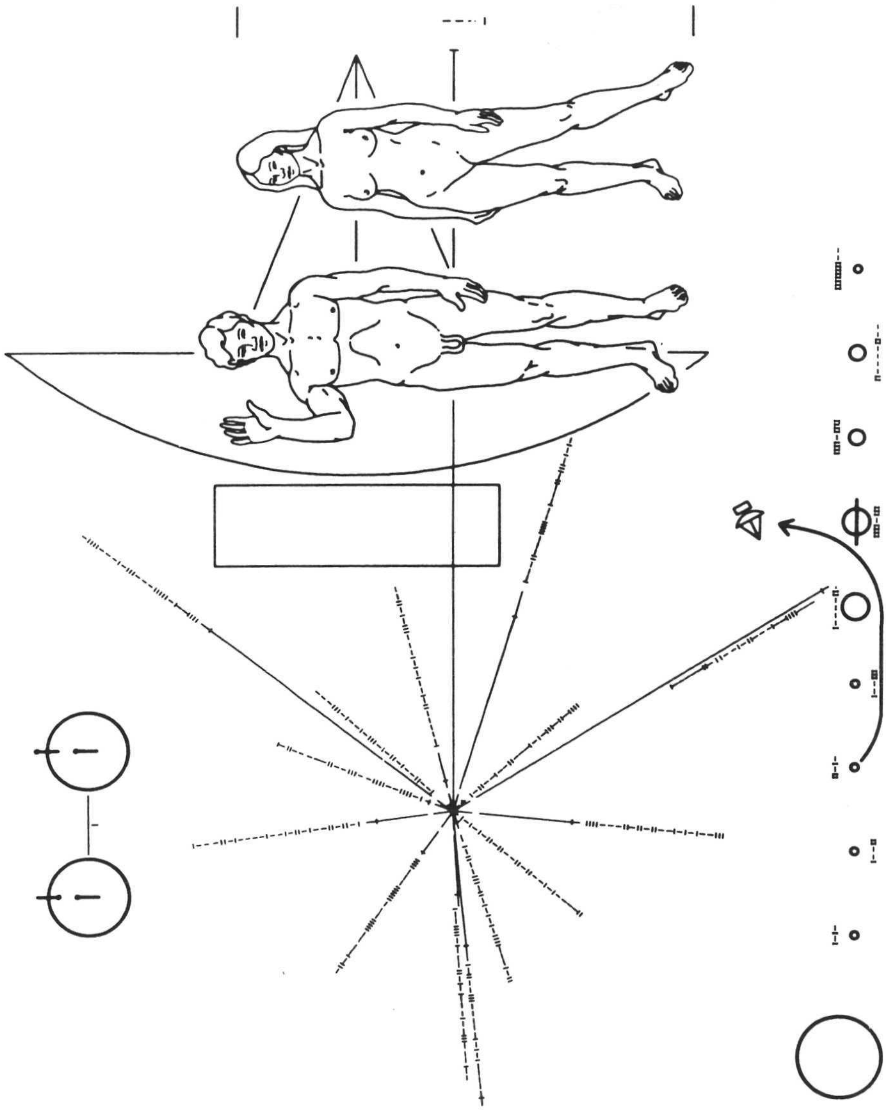
Pioneer *10* was launched by NASA from Cape Kennedy, Fla., March 2, *1972,* on a mission of two years or more to fly beyond the orbit of Mars, pass through the Asteroid Belt, and observe Jupiter closeup before being flung into a trajectory that will carry it continuously from the Sun.

The plaque design was etched into a gold-anodized aluminum plate 152 by 229 millimeters (6 by 9 inches) and 1.27 millimeters (0.050 inch) thick, attached to the spacecraft's antenna support struts in a position to help shield it from erosion by interstellar dust.

The radiating lines on the left of the plaque represent the positions of 14 pulsars – cosmic sources of radio energy – arranged to indicate our Sun as the home star of the launching civilization. The "1-" symbols at the ends of the lines are binary numbers that represent the frequencies of these pulsars at the time of launch of Pioneer F relative to that of the hydrogen atom shown at the upper left with a "1" unity symbol. The hydrogen atom is thus used as a "universal clock" and the regular decrease in the frequencies of the pulsars will enable another civilization to determine the time that has elapsed since Pioneer F was launched.

The hydrogen atom is also used as a "universal yardstick" for sizing the human figures and outline of the spacecraft on the right of the plaque. The hydrogen wavelength – about 8 inches – multiplied by the binary number representing "8" shown next to the woman gives her height – 64 inches. The figures represent the type of creature that created Pioneer. The man's hand is raised in a gesture of good will.

Across the bottom of the plaque are the planets, ranging outward from the Sun, with the spacecraft's trajectory arcing away from Earth, passing Mars, and swinging by Jupiter.



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APPENDIX C

BROTHERS IN THE ETERNAL COLD

By Archibald MacLeish
Author of "Land of the Free," "The American Cause," "J. B.," etc.; winner of two Pulitzer Prizes for poetry, one for drama.

Men's conception of themselves and of each other has always depended on their notion of the earth. When the earth was the World – all the world there was – and the stars were lights in Dante's heaven, and the ground beneath men's feet roofed Hell, they saw themselves as creatures at the center of the universe, the sole, particular concern of God – and from that high place they ruled and killed and conquered as they pleased.

And when, centuries later, the earth was no longer the World but a small, wet, spinning planet in the solar system of a minor star off at the edge of an inconsiderable galaxy in the immeasurable distances of space – when Dante's heaven had disappeared and there was no Hell (at least no Hell beneath the feet) – men began to see themselves not as God-directed actors at the center of a noble drama, but as helpless victims of a senseless farce where all the rest were helpless victims also, and millions could be killed in worldwide wars or in blasted cities or in concentration camps without a thought or reason but the reason – if we call it one – of force.

Now, in the last few hours, the notion may have changed again. For the first time in all of time, men have seen the earth: seen it not as continents or oceans from the little distance of a hundred miles or two or three, but seen it from the depths of space; seen it whole and round and beautiful and small, as even Dante – that "first imagination of Christendom" – had never dreamed of seeing it; as the 20th-century philosphers of absurdity and despair were incapable of guessing that it might be seen. And seeing it so, one question came to the minds of those who looked at it. "Is it inhabited?" they said to each other and laughed – and then they did not laugh. What came to their minds a hundred thousand miles and more into space – "halfway to the moon" they put it – what came to their minds was the life on that little, lonely, floating planet, that tiny raft in the enormous, empty night. "Is it inhabited?"

The medieval notion of the earth put man at the center of everything. The nuclear notion of the earth put him nowhere –

beyond the range of reason even – lost in absurdity and war. This latest notion may have other consequences. Formed as it was in the minds of heroic voyagers who were also men, it may remake our image of mankind. No longer that preposterous figure at the center, no longer that degraded and degrading victim off at the margins of reality and blind with blood, man may at last become himself.

To see the earth as it truly is, small and blue and beautiful in that eternal silence where it floats, is to see ourselves as riders on the earth together, brothers on that bright loveliness in the eternal cold–brothers who know now they are truly brothers.

From the N. Y. Times 12/26/68
by permission of the author

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APPENDIX D

CENSORSHIP OF SATELLITE BROADCASTS

Forces set in motion by communications satellites are now causing anxiety in the world's closed societies. The U. S. S. R. recently pushed a proposal in the U. N. that would allow any country to censor transmissions to that country from any other country's direct broadcast satellites.

Implications for society are expressed in the following speech given by Dr. Frank Stanton, Vice Chairman of the Columbia Broadcasting System, Inc., in Memphis, Tennessee, on October 4, 1972.

On August 8, the Foreign Minister of the Soviet Union, Andrei Gromyko, submitted for the consideration of the United Nations General Assembly the text of a proposed international convention governing satellite television broadcasts directly into homes. What this proposed convention asserts is that governments have the right to control television broadcasts from abroad via satellite to their people by controlling international broadcasts at their source. It is an unfortunate fact that the leaders of too many nations have a deadly fear of information which could lead their people to topple the regimes in power. Understandably, these leaders are interested in stringent preventative meassures. Hence the efforts of the Soviet Union have been encouraged by the acquiscence of other nations to a similar proposal from UNESCO. I want to return to this international proposal later.

The government of the Soviet Union can and does jam incoming foreign shortwave radio broadcasts, at a cost estimated as $300 million annually. It can and does punish its people for listening to foreign broadcasts. I am not addressing myself to the power of the Soviet government to do what it wishes within its own borders. The Soviet proposal to the United Nations, however, raises two new points.

It envisages not merely jamming incoming broadcasts, but also taking action directly against satellites themselves outside a receiving nation's territorial jurisdiction. The Soviet Union asks UN member states, including our country, to agree that any nation, on its own initiative, may destroy satellites to keep broadcasts from going directly into the homes of their own people. This would make censorship a principle of international law.

Undoubtedly the nightmare haunting the Kremlin is the possibility of its people hearing something other than their official government line—the chance that some future move like the invasion of Czechoslovakia might be reported in broadcasts directly into Russian homes, giving the lie to the idea that the invasion was joyfully received. What the Kremlin wants is assurance that it can seal off the Soviet people from everything but its own propaganda.

It is sometimes difficult for the Russians to make the distinction between their system of government communications media and ours of independent private communications entities. The Soviet Union sees no moral defect in giving governments, under international agreement, the right to orchestrate the flow of ideas. But such a right has no standing in this country, where communications media are private and the very first article of our Bill of Rights limits government authority over speech, press and thought.

What makes the USSR proposal more troublesome is that a climate of plausibility has been created for it, unbelievable as it may appear, by the United National Educational, Scientific and Cultural Organization—UNESCO, the organization conceived in the noblest of international idealism for the advancement of free and unfettered cultural exchange. UNESCO experts from more than a dozen countries put together a document that can only be described as a compromise in principle and a frightening danger in practice.

This astonishing UNESCO contribution, entitled "Draft Declaration of Guiding Principles on the Use of Satellite Broadcasting for the Free Flow of Information, the Spread of Education and Greater Cultural Exchange," will be submitted to the organization's General Conference this month. In general terms, the Declaration proclaims the people's right to freedom of information. In specific terms, however, the Declaration would have the United States accede as a matter of international law to any government's cutting off of its people from direct satellite television broadcasts—and not only television broadcasts but also, going the Russians one better, radio broadcasts as well. The rights which form the framework of our Constitution, the principles asserted in the Universal Declaration of Human Rights, the basic principle of the free movement of ideas, are thus ignored. And in their place an alien concept is proposed—a concept which gives the UNESCO Draft Declaration its clear meaning, the compromising of freedom.

The UNESCO Draft Declaration twists and turns. It commences with an altruistic allusion to "such international agreements as

may be necessary to promote the free flow of ideas by word and image." It cites the message of the Universal Declaration of Human Rights that "everyone has the right to seek, receive and impart information and ideas through any media and regardless of frontiers." It even states that "The objective of satellite broadcasting for the free flow of information is to ensure the widest possible dissemination, among the peoples of the world, of news of all countries, developed and developing alike."

This, however, turns out to be window dressing. Getting down to its real business, the UNESCO Draft Declaration declares "Each country has the right to decide on the content of the educational programmes broadcast by satellite to its people." And the Declaration does not stop there. "It is necessary," the document continues, "that States, taking into account the principle of freedom of information, reach or promote prior agreements concerning direct satellite broadcasting to the population of countries other than the country of origin of the transmission." Thus, in a single sentence, the Draft Declaration manages to combine lip service to freedom of information and a demand for prior censorship of broadcasts through government agreement and control.

In practical terms, the UNESCO Draft Declaration gives international sanction to government control of what people can see and hear in direct satellite transmissions from outside their national borders. This means that nobody may legitimately broadcast to the USSR without the agreement of the USSR. That is what UNESCO proposes, not just for the USSR but for every nation. And despite the inclusion of all the disclaimers, what this amounts to is clear and frightening acceptance of the very same principle which lies behind the Soviet Union's proposal to the United Nations.

Cooperation, understanding and trade between Russia and the United States certainly are in the interests of peace. In serving the interests of peace, however, it surely is not necessary to sacrifice basic human rights. In the final analysis, there can be no truly enlightened progress and hence no real peace without these basic human rights.

Regardless of what body exercises the power of the censor, the effect of both the Soviet Union draft and the UNESCO draft is to make it possible for every signatory government to assert control over the content of international broadcasts. Quite seriously, I do not see how our government, given our Constitution, can possibly enter into any agreement in which the rights of Americans to speak to whomever they please when they please are bartered away. And that is what both draft documents would do.

We recognize that although the United States by tradition believes in the free exchange of ideas, most other nations do not. That fact probably explains why the UNESCO Draft Declaration was adopted by a multi-nation committee. What is astonishing is that the draft was accepted by a body which included a delegate from the United States of America. Apparently he expressed no reservations, for none was recorded. The document hence went forward as a unanimous and unopposed recommendation.

Incredibly, in the ensuing months, wiser counsel has not prevailed, despite the reasoned protests of the White House Office of Telecommunications Policy and the United States Information Agency, both of which are strongly opposed to the Draft Declaration. Rather than face the issue forthrightly and squarely, the State Department's plan of action as of today presumably is merely to plead for postponement, and to vote against the Draft Declaration as a last resort—only if postponement fails.

The State Department's attitude is perhaps best described as "embarrassment" over the prospect of opposing the desires of developing countries, which support the Draft Declaration. What the Department obviously has in mind is an attempt to avoid a head-on confrontation and give everybody a tidy diplomatic out. But I submit that the central issue here transcends that kind of diplomacy. Delaying tactics, pleas that haste is unnecessary or further study is required are entirely out of place when the fundamental principle of free speech is at stake. There can be no temporizing. You don't negotiate free speech. The United States must do all within its power to block the path to international censorship.

We must indicate in unmistakable terms that we reject censorship today, that we will reject it tomorrow, that we will reject it whenever its head is raised.

To this end it is imperative that the Secretary of State instruct our delegation to the UNESCO General Conference two weeks hence to oppose the Draft Declaration and to oppose it head on. Any other course would be unworthy of our national heritage. When liberty is threatened, when freedom of thought is challenged, the policy of the United States must be resolute and uncompromising. Never can we concede a basic freedom in one circumstance and expect it to survive unchallenged in another.

And so, the great potential of the communications satellite for helping to open up the closed societies may be stillborn. The urgent need for the free flow of knowledge it could help provide

was described by Alexander Solzhenitsyn in his smuggled speech* accepting in absentia the 1972 Nobel Prize for Literature:

> "... newspaper headlines still display: 'No Right to Interfere in Our Internal Affairs.' Whereas there are no internal affairs left on our crowded earth. And mankind's sole salvation lies in everyone making everything his business; in the people of the East being vitally concerned with what is thought in the West, the people of the West vitally concerned with what goes on in the East."

d. 2

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APPENDIX E

SPACE TRAVEL PROSPECTS

Excerpt from "Human Consequences of the Exploration of Space" by Freeman Dyson, Institute for Advanced Study, Princeton, N. Y., in the Bulletin of the Atomic Scientists, September 1969, Volume XXV, Number 7, p. 12.

How long it will take for space travel to become socially important is mainly a matter of economics, a field in which I have no competence. I will only put forward a few tentative remarks to suggest that the time should be measured in decades rather than in centuries. There is a prevalent view among the educated public that space travel is necessarily and permanently so expensive that it can never be made available to large masses of people. I believe this view to be incorrect.

An interesting analysis of the economics of our existing space operations was made by Theodore Taylor ("Propulsion of Space Vehicles" in Marshak "Perspectives in Modern Physics," Interscience, 1966). He calculated the cost of running a commercial jet-plane service from New York to Los Angeles under the following ground rules:

(1) There shall be no more than one flight per month.
(2) The airplane shall be thrown away after each flight.
(3) The entire costs of Kennedy and Los Angeles airports shall be covered by the freight charges.

Under these rules, which are the rules governing our present space program, the cost of freight between New York and Los Angeles is comparable to the cost of putting freight into orbit. The point of this calculation is that the economies of commercial airline operations are economies of scale and of efficient organization. There is no basic physical or engineering reason why it should be enormously cheaper to fly to Los Angeles than to fly into orbit.

I will not go here into a technical discussion of the problems of space propulsion. In order to make space travel cheap we need two things. The first is a reliable vehicle, preferably an air-breather, which can take off from an airport, fly itself directly into orbit, re-enter and land, and be ready to repeat the operation day after day. The second is a massive volume of traffic and a correspondingly massive sale of tickets. I believe the second of

these requirements will be met automatically within a few decades after the first is achieved. There are formidable technical problems involved in producing the re-usable orbital vehicle, but I do not believe the problems are permanently insoluble. Few people in the existing space program have worked on these problems, because the policy has been to do things fast rather than cheaply. The present cut-back may in fact encourage more long-range work on cheaper vehicles.

I hesitate to make numerical predictions, but it may help to make my remarks meaningful if I state my actual expectations for the time-scale of these developments. I expect that sometime between 50 and 100 years from now we will have space travel with a volume of traffic and a cost to the passengers comparable with our present intercontinental jet flights. This prediction has the great advantage that if the reality exceeds my hopes I may be here to enjoy it, whereas, if I am proved wrong the other way, I will never know it.

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APPENDIX F

THE IMPOSSIBLE DREAM

Excerpt from "A Commercial Airline Looks at the Space Shuttle" by Mr. Najeeb E. Halaby, Chairman and Chief Executive Officer, Pan American World Airways. Delivered to the Society of Experimental Test Pilots, September 16, 1971.

The "Impossible Dream" we insist on dreaming is that of the Space Shuttle as an air transport, carrying passengers from New York to Tokyo – in 45 minutes, or from Los Angeles to Rome in 40.

The key to practical application of the space shuttle is basically the same as the key to developing commercial aircraft; reduction of the cost per pound of payload. Since it takes much less energy to put an object in earth orbit than to fly the same object across the United States, there is no reason why the cost of space shuttle operations should not become as low as or lower than that of jets.

I can visualize a rocket-powered vehicle with 100 passengers – not counting stewardesses – launched vertically in suborbital trajectory at the precise azimuth for its intended destination, reentering the atmosphere without excess g-forces, gliding unpowered to an altitude where its conventional jet engines will be started, then landing on a runway like a conventional airliner. Obviously this dream is a long way down the line, and many inventions remain to be invented before it occurs.

And we have learned – or we had better have learned – that from here on out, our future will depend not on a few leaders, but on a concerned and aroused public at large. So our design criteria for a space shuttle are not related simply to its efficiency, its speed, its fuel consumption, its payload, and all those other traditional concerns. Superimposed on these already-difficult specifications is the requirement that the Space Shuttle fulfill a real need of people; that it operate at a cost the public can afford; and that it operate within parameters of social acceptability.

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APPENDIX G

THE VALUE OF SPACE ACTIVITY FOR DEVELOPING COUNTRIES

Excerpts from a speech by Vikram Sarabhai, Chairman, Indian National Committee for Space Research, presented at the American Astronautical Society National Meeting, San Francisco, California, August 18-20, 1965.

At first sight it may appear odd that a developing nation such as India, where the annual per capita income is about 80 dollars at current prices, where the average expectancy of life is 45 years and the population grows by about 13 million each year, should think of things other than the immediate problems of population control and of providing food, clothing, housing, education and the social services. What is the value of space research to such a country?

Clearly the development of a nation is intimately linked with the understanding and application of science and technology by its people. It has sometimes been argued that the application of technology by itself can contribute to growth. This is certainly true as an abstract proposition, but fails in practice. Witness the state of development and social structure of countries of the Middle East, where for decades resources of oil have been exploited with the most sophisticated technology. History has demonstrated that the real social and economic fruits of technology go to those who apply them through understanding. Therefore a significant number of citizens of every developing country must understand the ways of modern science and of the technology that flows from it.

An ability to question basic assumptions in any situation is fostered by probing the frontiers of science, whatever field one may be engaged in, whether it is Biology, Genetics, Atomic Science or Space Research. It is this ability rather than an empirical hit and miss approach which proves most effective in tackling the day to day problems of the world. It follows from this that countries have to provide facilities for their nationals to do front rank research within the resources which are available. It is equally necessary, having produced the men who can do research to organize task oriented projects for the nation's practical problems.

The role of space activities in stimulating the growth of technology and industry in advanced fields such as electronics,

communications, cybernetics and in materials engineering is well recognized in the advanced nations. This applies equally to developing nations such as India.

International cooperation in science contributes to the creation of a climate for development which is essential in an age where colonialism has largely ended. When a nation succeeds in setting up a scientific programme with sounding rockets, it develops the nucleus of a new culture where a large group of persons in diverse activities learns to work together for the accomplishment of a single objective.

Agriculture is the most important activity on the sub-continent of India. A large majority of the population of 480 millions earn their livelihood from this occupation which is largely dependent on rain that occurs during the monsoons. It is hardly necessary in this audience to stress therefore the importance to India's economy of a better understanding of the processes by which the monsoon rains occur, processes which commence over the vast Indian Ocean, where there are relatively few observing stations undertaking even the normal observations at surface or with balloons. What applies to the economy of India applies to the economy of most of the countries in the Indian Ocean region. Space meteorology which permits the acquisition of valuable data from satellites as well as with the use of sounding rockets has therefore a special significance for us.

Another area of practical importance is the field of satellite communications. Geographically situated as it is at 75° to 90° E meridian, with a volume of international telecommunications second only to Japan in Asia, a satellite communications earth station is of great importance not only for national needs, but for international hook-ups. Assisted by the U. N. Special Fund, an Experimental Satellite Communications Earth Station is now being set up. Independent of this, it is proposed to have a commercial station in the future. The experimental station would provide unique facilities for training scientists and technologists, particularly from the developing nations, in the new field of space communications.

With continued cooperation from the advanced nations, we hope through this activity not only to stimulate the progress of our nation, but also to contribute to science.

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APPENDIX H

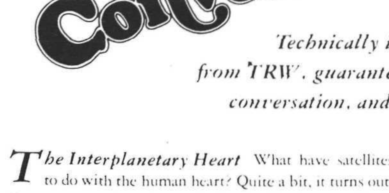
Conversation Pieces

Technically intriguing items from TRW, guaranteed to add luster to your conversation, and amaze your friends.

The Interplanetary Heart What have satellites to do with the human heart? Quite a bit, it turns out. Outer space and the human body are alike in that objects which man places in either must operate unattended in a demanding environment for long periods of time.

Consider, for example, TRW's Pioneer-Jupiter satellite. Even though it travels fast enough to get to the moon in eleven hours, it takes Pioneer around two years to get to Jupiter, the first of the outer planets. During its long flight away from the sun, the satellite's electrical power is supplied by a device which uses the heat from a nuclear isotope to generate electricity (a radioisotope thermoelectric generator). In addition, some of Pioneer's delicate instruments are protected from low temperature damage by nuclear-fueled heaters.

POWER SUPPLY FOR HEART-ASSIST PUMP



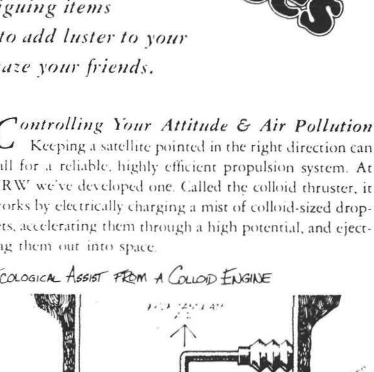
The technology associated with such long-lived, reliable heat sources is now being applied to the human heart. TRW scientists are working on suitable nuclear energy sources for heart-assist pumps, developing radioisotope heat capsules and studying thermal converters.

Placed within the body, the capsule releases heat energy through low radiation level radioactive decay, and the converter turns the energy into power for the heart pump (The motor for the pump, incidentally, is based on those used in the Minuteman guidance and control gyrocompass, which have been operating at 16,000 rpm for more than four years.)

The severe reliability levels called for by flight to an outer planet make you refine and sharpen your technology to extremes, whereupon it suddenly becomes useful here at home within the body of a living man.

Controlling Your Attitude & Air Pollution Keeping a satellite pointed in the right direction can call for a reliable, highly efficient propulsion system. At TRW we've developed one. Called the colloid thruster, it works by electrically charging a mist of colloid-sized droplets, accelerating them through a high potential, and ejecting them out into space.

ECOLOGICAL ASSIST FROM A COLLOID ENGINE



Recently, we put this principle into an industrial smoke stack. It removed 99% of the particulate matter (such as fly-ash) billowing forth into the atmosphere. A series of needles emitting positively charged droplets were accelerated toward the negatively charged walls of the stack. On the way, they entrained almost all of the dust particles. Result: a smokeless stack.

Now we are at work with an asphalt association in removing particles from the smoke of asphalt plants. They say it's much better than the expensive solutions they have tried in the past.

We're very happy about that. When people at cocktail parties complain to us about modern technology, we have still another rejoinder.

For further information, write on your company letterhead to:

TRW
SYSTEMS GROUP

Attention: Marketing Communications, E2 9043
One Space Park • Redondo Beach, California 90278

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APPENDIX I

SPENDING MONEY DIRECTLY OR . . .

Excerpt from ". . . for the benefit of all mankind," General Electric Co., November 1971, pages 10 & 11.

Some critics say "Why not spend money directly on the medical, environmental, educational and communications projects, rather than to wait for benefits from large efforts like the space program?"

Well, it just doesn't work that way.

On specific pin-pointed research efforts no matter how important, such as a cure for a devastating disease you don't really know what you're looking for; when you do, you don't always have the parallel technologies as "tools" with which to look. But if you have a broad-front major goal such as space exploration you must move technologies forward on such a wide front that the many results of advancing many technologies can be integrated to reach the solution of many problems otherwise not solvable.

For example, the discovery of a polio vaccine brought peace of mind to millions. It was a remarkable medical achievement by dedicated people. What's overlooked is that it would not have been possible without the development of electron microscope technology that had an origin entirely apart from a polio vaccine search.

You need a large program funded and motivated around a national goal, with wide, demanding and unprecedented technical requirements which generate breakthroughs across a broad spectrum of technologies. These breakthroughs then become "tools" that make possible the generation of unrelated breakthroughs even in fields not directly connected to the original program.

Thus, technical or scientific breakthroughs of major social importance, such as a cancer cure, may be generated in a relatively abrupt manner because some other breakthrough yielded a key "tool," or a fundamental piece of knowledge, hitherto unknown but indigenous to the solution. This sort of thing does not come about across the general technological front by attempting to decide beforehand precisely what breakthroughs should be funded in order to precisely generate other breakthroughs. Man, unfortunately, does not have the clairvoyance to write a scenario in accordance with which his technical and scientific breakthroughs and discoveries can be set up ahead of time, to occur in a precise schedule so as to reinforce each other.

If man had this precognition, our current important medical, social, scientific and technical achievements would have already been realities a long time ago and with much less blood, sweat and tears.

Typical of such a large program funded and motivated around a major national objective is a war. And, as mentioned before, rapid technical and scientific advance results therefrom. The space program, on the other hand, represents the same approach, but is not a war. The space program has had a tremendous forcing effect on rapidly advancing our science and technology in general. As mentioned, it has compressed several decades of "normal" technological advance into less than one, and it has resulted in such progress in virtually every scientific and technological discipline, to the great benefit of mankind.

It is most important again to point out that the objective is not to *replace* desired social action programs with technology programs, but rather *not* to *abandon* technology because of our pressing need for social action programs. To repeat what was mentioned before, the need is a *balanced* combination, so that solutions to our social problems can be accelerated by technology advance – which is the real *viable* route to successful emergence from our dilemma.

For it is this multi-faceted impact of the technology dollar that is producing the technical breakthroughs that will make it possible to control environmental pollution, advance medical science, extend education to the backward areas of the world, build cheaper and better housing and, above all, generate the dynamic new industrial technologies that create new products, new markets and new jobs.

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APPENDIX J

EXPLANATION TO THE ARTIST

An orientation provided by Dr. Hereward Lester Cooke, Curator of Painting, National Gallery of Art, to the artists who volunteered to participate in the space art project.

It seems certain that the age we are living in will go down as a red-letter epoch because the first steps in space exploration are going to make a hinge in the fate of mankind. Not since the lung-fish slithered out of the Paleozoic slime have living creatures sought to change their environment, and not since Columbus have men dared to enter more dangerous and mysterious regions. Perhaps in space we will find greener pastures; perhaps we will find nothing but infinite hositility and will return to realize that life on this planet is more precious than we ever imagined. Whatever the results, space exploration is changing history.

The effort we are making in this country represents the frontiers not only of technical achievements, but also of the imagination. The space effort in every way is a worthy theme for the artist. Space travel started in the imagination of the artist, and it is reasonable that artists should continue to be the witnesses and recorders of our efforts in this field.

NASA decided to ask artists to supplement the record after reviewing the documentation of the first few years of the space age. It was realized that important aspects of the story were missing. When a major launch takes place at Cape Kennedy, more than two hundred cameras record every split second of the activity. Every nut, bolt, and miniaturized electronic device is photographed from every angle. The artist can add very little to all this in the way of factual record. But, as Daumier pointed out about a century ago, the camera sees everything and understands nothing. It is the emotional impact, interpretation, and hidden significance of these events which lie within the scope of the artist's vision. An artist may depict exactly what he thinks he sees, but the image has still gone through the catalyst of his imagination and has been transformed in the process.

So style in this assignment is unimportant. If you see events in non-objective terms, represent them this way. NASA is commissioning your imagination, and we want records of fleeting impressions and poetic by-products of thought as much as precise documents of optical experience. What is important is that the artist gives us his personal and sincere interpretation. His work will

not be juried, judged, or evaluated when it arrives at NASA, at least not by this generation, but it will become a permanent record of an individual's talent and perception, and in this way is a sliver of immortality.

There are no restrictions regarding medium, style, size, subject, shape, except that the materials used must be of proven permanence. I do not want faded and flaking pictures in a government archive.

The artist like the scientist must reorient some of his thinking in the space environment. Have you ever thought what the human body really looks like in a state of weightlessness? Or what it means to have no up or down? That a glass of water is just as right upside down as in any other position? Or that Leonardo's optical perspective does not apply to the moon landscape and a distant mountain is just as sharp and colorful as a pebble six inches away? Or that space is a whirlpool of unseen waves through which the earth swims, leaving a wake like a ship? Or that the electrical impulses which send pictures from the moon are about as strong as the static generated by a butterfly's wings? Or that the earth in relation to a solar flare-up is about the same as a pinhead in the flame of a match? All of our concepts of size, speed, number, mass, and even life are quaint and obsolete in this age. And have you thought of the role of man, who not only controls but is also caught in the web of the monstrous machines he has made? The metaphysical aspects of space are as fascinating as the physical and are equally within the scope of the artist.

There are several more direct reasons for commissioning drawings and paintings. First, NASA is anxious to document the space effort in every way possible. From my own point of view, I am convinced that artists should be key witnesses to history in the making, and that in the long run the truth seen by an artist is more meaningful than any other type of record. Second, I want to build up a collection of drawings and paintings which will convey to future generations some of the excitement and wonder that we feel as we cross the space threshold. I also want these paintings to stand on their own merit as works of art, quite apart from the subject matter. I hope future generations will realize that we have not only the scientists and engineers capable of shaping the density of our age but artists worthy to keep them company.

For best results, I am sure that it is good policy to leave the artists alone. Therefore, I may indicate subjects which seem adaptable, but in general you will be completely free to draw, paint, and record whatever strikes you as significant and unique. We are commissioning not only the artist's skill, but also his

perception and his imagination, and for best results neither should be dictated or forced; therefore you are free to use whatever style you wish.

One thing I insist on. Every drawing made on site, regardless of how slight, must be saved and eventually added to the permanent archive. The reason for this is that on-the-spot sketches often have an impact and immediacy which finished works of art lack. I became aware of this when working on an exhibit of artwork which had been commissioned during the Civil War. Often it was the crumpled scrap of paper with the sketch of a figure or incidental group which, after a hundred years, had the most meaning in conveying the real character of that war. Therefore, please save every drawing, and, after you have finished, send it along. It will be carefully preserved and eventually may fill a gap in the future's estimate of us and our endeavors.

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APPENDIX K

THE POETRY OF SPACE

Apparently the first poem physically sent into orbit was launched on the TRAAC Satellite 1961 α n2 on Nov. 15, 1961, inscribed on an instrument panel. It was composed by Professor Thomas G. Bergin, Professor of Romance Languages, Yale University at the request of Dr. G. F. Pieper, then of the Johns Hopkins University Applied Physics Laboratory, to dedicate a poem to the new field of space research.

SPACE PROBER

From Time's obscure beginning, the Olympians
Have, moved by pity, anger, sometimes mirth,
Poured an abundant store of missiles down
On the resigned, defenceless sons of Earth.

Hailstones and chiding thunderclaps of Jove,
Remote directives from the constellations:
Aye, the celestials have swooped down themselves,
Grim bent on miracles or incarnations.

Earth and her offspring patiently endured,
(Having no choice) and as the years rolled by
In trial and toil prepared their counterstroke–
And now 'tis man who dares assault the sky.

Fear not, Immortals, we forgive your faults,
And as we come to claim our promised place
Aim only to repay the good you gave
And warm with human love the chill of space.

In 1962 when the Mariner II spacecraft was on its way to Venus, the following poem, written by an employee, appeared in the house organ of the Jet Propulsion Laboratory, Pasadena, California.

L'ENVOI
(THE SENDING)

Mariner, I think about you often
Child of my making you are not,
But a strange new issue - secret, still

There you stood - resplendent, golden
Gangling phoenix with nonavian bones
Alone, aloof, behind the big blue doors

No nest, no trials for you, oh bird
All, all experience in the breeding
Just once the burn, the thrust, the leap

Sailing you are, on the sea of the air
Out and quiet, glistening still
Slowly lifting your arms to the Sun

And no return, oh beautiful bird
Soaring, silent, child of the void
The mind strains, it longs to follow

Virginia S. Anderson

On the following pages are rare items – space poetry by internationally recognized authors.

The Moon Ground

by JAMES DICKEY

You look as though
You know me, though the world we came from is striking
You in the forehead like Apollo. Buddy,
We have brought the gods. We know what it is to shine
Far off, with earth. We alone
Of all men, could take off
Our shoes and fly. One-sixth of our weight, we have gathered,
Both of us, under another one
Of us overhead. He is reading the dials he is understanding
Time, to save our lives. You and I are in earth
light and deep moon
shadow on magic ground
Of the dead new world, and we do not but we could
Leap over each other like children in the universal playground
Of stones
but we must not play
At being here: we must look
We must look for it: the stones are going to tell us
Not the why but the how of all things. Brother, your gold face flashes
On me. It is the earth. I hear your deep voice rumbling from the body
Of its huge clothes Why did we come here
It does not say, but the ground looms, and the secret
Of time is lying
Within amazing reach. It is everywhere
We walk, our glass heads shimmering with absolute heat
And cold. We leap slowly
Along it. We will take back the very stones
Of Time, and build it where we live. Or in the cloud
striped blue of home, will the secret crumble
In our hands with air? Will the moon-plague kill our children
In their beds? The Human Planet trembles in its black
Sky with what we do I can see it hanging in the god-gold only
Brother of your face. We are this world: we are
The only men. What hope is there at home
In the azure of breath, or here with the stone
Dead secret? My massive clothes bubble around me
Crackling with static and Gray's
Elegy helplessly coming
From my heart, and I say I think something
From high school I remember Now
Fades the glimmering landscape on the sight, and all the air
A solemn stillness holds. Earth glimmers
And in its air-color a solemn stillness holds
It. O brother! Earth-faced god! APOLLO! My eyes blind
With unreachable tears my breath goes all over
Me and cannot escape. We are here to do one
Thing only, and that is rock by rock to carry the moon to take it
Back. Our clothes embrace we cannot touch we cannot
Kneel. We stare into the moon
dust, the earth-blazing ground. We laugh, with the beautiful craze
Of static. We bend, we pick up stones.

VOYAGE TO THE MOON

By Archibald MacLeish

Presence among us,

wanderer in our skies,

dazzle of silver in our leaves and on our
waters silver

O
silver evasion in our farthest thought–
"the visiting moon". . . "the glimpses of the moon" . . .

and we have touched you!

From the first of time,
before the first of time, before the
first men tasted time, we thought of you.
You were a wonder to us, unattainable,
a longing past the reach of longing,
a light beyond our light, our lives–perhaps
a meaning to us . . .

Now
our hands have touched you in your depth of night.

Three days and three nights we journeyed,
steered by farthest stars, climbed outward,
crossed the invisible tide-rip where the floating dust
falls one way or the other in the void between,
followed that other down, encountered
cold, faced death–unfathomable emptiness . . .

Then, the fourth day evening, we descended,
made fast, set foot at dawn upon your beaches,
sifted between our fingers your cold sand.

We stand here in the dusk, the cold, the silence . . .

and here, as at the first of time, we lift our heads.
Over us, more beautiful than the moon, a
moon, a wonder to us, unattainable,
a longing past the reach of longing,
a light beyond our light, our lives–perhaps
a meaning to us . . .

O, a meaning!

over us on these silent beaches the bright
earth,
presence among us

From the N.Y. Times, 7/21/69
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APPENDIX L

1972 LAUNCH SCHEDULE

Name	*Launch date*	*Vehicle*	*Range*	*Mission/Remarks*
Intelsat IV-F-4	Jan. 23	Atlas/ Centaur	KSC	Global Communication Satellite to form part of a global communication, commercial satellite system. Launched for COMSAT.
HEOS-A 2	Jan. 31	Delta	WTR	Investigation of interplanetary space and of the high latitude atmosphere and its boundary in the region around the northern central point. Launched for ESRO.
Pioneer 10	Mar. 2	Atlas/ Centaur	KSC	Flight to Jupiter; flight time: two years
TD-1	Mar. 12	Delta	WTR	Study of solar and terrestrial relationship. Launched for ESRO.
Apollo 16	Apr. 16	Saturn V	KSC	Manned lunar landing mission: To furnish additional knowledge of the Moon and its history. Astronauts: J. W. Young, T. K. Mattingly and Charles Duke.
Intelsat IV-F 5	June 13	Atlas/ Centaur	KSC	Launch for COMSAT
ERTS-I	July 23	Delta	WTR	First Earth Resources Technology Satellite
MTS	Aug. 14	Scout	Wallops	Meteoroid Technology Satellite for measurement of meteoroid penetration rates.
OAO-C	Aug. 21	Atlas/ Centaur	KSC	Orbiting Astronomical Observatory to study stars.
IMP H	Sept. 13	Delta	KSC	Study cislunar radiation environment over significant portion of solar cycle; interplanetary magnetic field and Earth's magnetosphere. Develop solar-flare prediction capability and determine radiation hazard for manned missions.
ITOS-D	Oct. 15	Delta	WTR	Operational Meteorological Satellite funded by NOAA.
SAS B	Nov. 15	Scout	SM/ETR	Gamma Ray Astronomy: Performs a sky survey of high energy gamma radiation from the celestial spheres, to determine the extent of primary galactic gamma radiation and to ascertain presence of gamma ray sources.
AEROS	Dec. 8	Scout	WTR	To measure the main aeronomic parameters determining the state of the upper atmosphere and the solar ultraviolet radiation in the wavelength band of main absorption. German cooperative satellite.
Nimbus E	Dec. 12	Delta	WTR	Research and development meteorological satellite leading to advanced operational weather satellites for global sounding of atmosphere.
Telsat A	Nov. 10	Delta	ETR	Domestic Communication Satellite, Canada
ESRO-IV	Nov. 22	Scout	WTR	To measure neutral and ionized particles in the ionosphere. Launch for ESRO.
Apollo 17	Dec. 6	Saturn V	KSC	Last of the Apollo missions. Manned lunar landing to furnish additional knowledge of the Moon and its history. Astronauts: Eugene Cernan, Ron Evans, Harrison Schmitt.
Intelsat IV-F-6	Dec.	Atlas/ Centaur	KSC	Global communication satellite to form part of a global communication commercial satellite system. Launched for COMSAT.

December 12, 1972

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APPENDIX M

SPACE DELIVERY SERVICE

A significant spur to the space research plans of many nations is President Nixon's recent offer of non-profit U. S. launch services to the world. One news article described the announcement as follows:*

NIXON EXTENDS SPACE LAUNCH SERVICES TO WORLD

President Nixon announced on Monday a policy to extend the present space launch assistance now available to the European Space Conference to the rest of the world for satellite projects for peaceful purposes "on a non-discriminatory, reimbursable basis."

The President, in announcing the "global launch assurance policy," affirmed "the need for a dependable capability which would make it possible for nations to have access under equal conditions to the advantages which accrue through space applications."

The most dramatic effect of this new policy could be the development of a joint U.S.–China space launch program. The White House said it expects Japan to be one of the first to seek the advantages, however. On the other hand, the Soviet Union, with a space launch rate almost three times that of the U. S. at the present time, is not expected to be an early user of U. S. launch vehicles.

United States Policy Governing The Provision Of Launch Assistance

I. United States launch assistance will be available to interested countries and international organizations for those satellite projects which are for peaceful purposes and are consistent with obligations under relevant international agreements and arrangements, subject only to the following:

A. With respect to satellites intended to provide international public telecommunications services:

1. The United States will provide appropriate launch assistance for those satellite systems on which Intelsat makes a favorable recommendation in accordance with Article XIV of its definitive arrangements.

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*Space Business Daily, Wed., Oct. 11, 1972, Vol. 64, No. 25, p. 179-180.

2. If launch assistance is requested in the absence of a favorable recommendation by Intelsat, the United States will provide launch assistance for those systems which the United States had supported within Intelsat so long as the country or international entity requesting the assistance considers in good faith that it has met its relevant obligations under Article XIV of the definitive arrangements.
3. In those cases where requests for launch assistance are maintained in the absence of a favorable Intelsat recommendation and the United States had not supported the proposed system, the United States will reach a decision on such a request after taking into account the degree to which the proposed system would be modified in the light of the factors which were the basis for the lack of support within Intelsat.

B. With respect to future operational satellite applications which do not have broad international acceptance, the United States will favorably consider requests for launch assistance when broad international acceptance has been obtained.

II. Such launch assistance will be available, consistent with U. S. laws, either from U.S. launch sites (through the acquisition of U.S. launch services on a cooperative or reimbursable basis) or from foreign launch sites (by purchase of an appropriate U. S. launch vehicle). In the case of launchings from foreign sites the United States will require assurance without prior agreement of the United States.

III. With respect to the financial conditions for reimbursable launch services from U. S. launch sites, foreign users will be charged on the same basis as comparable non-U. S. Government domestic users.

IV. With respect to the priority and scheduling for launching foreign payloads at U. S. launch sites, such launchings will be dealt with on the same basis as U. S. launchings. Each launching will be treated in terms of its own requirements and as an individual case. When it becomes known when a payload will become available and what its launch window requirements will be, the launching will be scheduled for that time. Should a conflict arise, the United States will consult with all interested parties in order to arrive at an equitable solution.

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APPENDIX N

SATELLITE-PECULIAR ADVANTAGES

From "The Impact of Space Technology on the Geophysical Sciences" by S. Fred Singer, Dean, School of Environmental and Planetary Sciences, University of Miami, Coral Gables, Florida; Proceedings of the American Astronautical Society, San Francisco, Aug. 18, 1965.

1.1 Advantages Peculiar to Satellites

The chief distinguishing features of a satellite are:

(1) Primarily its location which leads to the possibility of continuous observations above the absorbing effects of the atmosphere. In order to maintain itself the satellite must be located above the appreciable atmosphere which in practice means the exosphere, about 500km, well above the ionospheric regions.

(2) The uniform coverage of the earth which a satellite can furnish if it is in a suitable orbit.

From these major points follow many minor points in which a satellite may be superior to earth-bound instrumentations.

(i) It is capable of nearly simultaneous measurements of the whole earth and therefore can give an instantaneous picture of the phenomenon under study.

(ii) It can make a large number of these simultaneous measurements one after the other, and so average out transient effects.

(iii) By being at high altitudes it can often de-emphasize disturbances which exist near sea level and are caused by local anomalies.

(iv) In some cases a satellite measurement can be made to a better precision than a sea-level measurement since temperature conditions remain constant and other environmental factors can be more easily controlled.

(v) Finally a satellite measurement may often be less expensive from the point of view of effort and cost than equivalent measurements with other tools such as sea-level expeditions, airplanes, balloons and rockets.

Most important, the satellite can perform some measurements which cannot be conducted by any other means.

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APPENDIX O

SATELLITES
Watch Over Your Farm

Do you remember how shocked you were in October 1957? That was when you heard the news that the Soviet Union had sent into orbit the world's first satellite, Sputnik I. And remember how when you were plowing you probably looked skyward and wondered if there really was something out there?

If you were like all other Americans, you also felt a little humiliated by the Soviets' achievement. But an energetic U.S. Senator and the then Senate majority leader—Lyndon B. Johnson—was not interested in the United States being second in anything, much less space. He led a drive in the Congress that culminated in the establishment of the National Aeronautics and Space Administration (NASA). The space race was on.

Unless you were more foreseeing than most, you would have never believed it possible that in the 1970's a highly sophisticated satellite that can't be seen would be circling the earth and perhaps helping you farm better.

Yet it's true. On July 23, 1972, after ten years of research, ERTS-1 (Earth Resources Technology Satellite No. 1) was launched into orbit. Circling the earth every 103 minutes, it photographs your farm every 18 days from 570 miles up. Each pass covers the same hour of day, providing a continuing history of your farm's state of health.

To keep ERTS charged for life of a year or longer, its butterfly wings of "solarcells" are angled for receiving light energy from the sun. Data is stored "up there" on tape. Upon command, the data is released to a receiving station. Well over 100 commands can be sent to the satellite: turn cameras on and off . . . change orbit to higher or lower . . . turn experiment on and off.

Potential benefits to agriculture are beyond estimate. USDA ventures that each dollar spent on this remote sensing research will return at least five. Scientists repeatedly state that farm people will be the chief benefactors. Farm benefits are legion; here are a few:

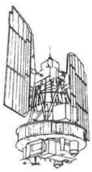
- Turn guesswork into scientific farming.
- Determine exactly how many acres of crops were destroyed by hail or by high water.
- Sight boll weevil hibernation areas on Texas High Plains and South Mississippi; pink bollworm in Imperial Valley.
- Measure soil moisture and soil temperature. Should I irrigate, shall I plant?
- Rangelands overgrazed or could they carry more cattle? (Range plant leaves will show red in infrared photography.)
- Amounts of favorable vegetation for screwworm survival. A proposed program in Texas and Republic of Mexico.
- Tell farmers the time to plant, spray, harvest.
- Show progress of the "green wave" in spring as green moves north, or "brown wave" in fall as it moves south. Valuable to cattle grazing, custom harvesting, crop reporting.
- Foreign markets. One USDA official foretells: United States will know three months before it happens how much wheat will be harvested in Russia and China.
- Monitor air, water pollution. Is it my farm muddying the stream, or is it highway construction upstream?
- Like cancer tests, early detection will pay off. Plant diseases—in early stages undetected by human eyes—can be spotted by infrared.
- Monitor steers and calves bought in South Texas or Florida and moved north. What is condition of wheat pasture? Will steers have to be moved off of pasture to feedlot early because of drouth or greenbugs? Remote sensing will be able to tell you well ahead of time.

Just what is the secret of ERTS's ability to see so much so quickly? This special ability is called—in technical terms—remote sensing.

Just what is remote sensing? Your Instamatic camera is a remote sensor. So is your eye studying a pretty knee. Your fingers are not. What is all this we hear about ERTS's keen ability to distinguish crops (wheat from barley, hopefully)? Quite simple. Look at yourself—you are unique. When you sign your name your signature is different from that of any other person's on earth. Just so, each object on earth—animate or inanimate—reflects a different amount of heat. Each has its unique "spectral signature." Your eyes cannot see this difference. But sensors on a satellite can read amount of heat and report in infrared photographs,

(Continued on page 42)

By JOHN McKINNEY, *Photographic Editor*



Satellites Watch Over Your Farm *(Continued from page 38)*

enabling you to see many hidden phenomena.

Over ten years have gone into recognition study of these various "signatures." And outerspace people, working feverishly since ERTS orbited last summer, say much time will be needed to refine this exacting science. Estimates run 5 to 20 years. However, it has already been found that when any kind of stress (such as drouth, disease, insects) strikes a plant it suffers a breakdown of green chlorophyl in the leaves. By infrared, stressed leaves appear pink, white, brownish . . . in contrast to a red image for the foliage of a healthy plant. (*Progressive Farmer*—in a national first—told you exclusively about infrared space photo possibilities: "Infrared Unlocks Nature's Secrets," March 1967.)

The present ERTS pictures, from 570 miles up, define crop fields in some degree, while the color is especially good. And though the photography is a promising forerunner of a valuable farm tool to come, picture detail is not yet sufficiently sharp to detect minute crop stresses. In perfecting the sensing technique, aircraft are being employed to follow up for closer detail—flying in high altitudes along the fringes of space at 65,000 feet, and on down to a mere 1,000 feet.

Finally, after planes, comes ground-truthing research, plain footwork. Plants are checked closeup to establish the precise shade of color signature for a given crop situation by a corps of "ground truthers." (See photos.) Age of the crop is important since the color changes delicately from seedling to maturity. Our cover this month shows ground-truther Harold Greene of USDA-ASCS, Imperial County, Calif., in action. Says Greene: "Yes, this Imperial Valley might be called the cradle of outerspace sensing for agriculture. We have an unusually clear atmosphere out here. In 1969 the manned Apollo 9 in orbit got a sharp infrared picture of our Salton Sea and farms. The picture became a classic, and millions were inspired to lend impetus to developing the present ERTS."

ERTS-1 is to have a helper. The manned Skylab, a first, is scheduled for launch in May 1973. A day or two after launch, if all goes well, three astronauts will go up and dock with the orbiting craft and remain aboard for 28 days. Skylab astronauts will operate cameras and bring back exposed film. They will report on farm crops, land, water — same as ERTS that carries no film.

When this initial team returns, there will be a study of findings over a period of about 60 days. Then a second team of three will go up and stay 56 days this time. After another break of about 30 days for deliberation on earth, a third and final team will go up for 56 days. (The first 56-day trip will establish a new record for length of time in space. Russians have held the record, with 24 days. First joint venture of the United States and Russia working together will be the Apollo Sayuzs spacecraft scheduled for launch in mid-1975.)

The second ERTS satellite is scheduled for launch in late 1973. Like all new inventions, the present ERTS has some defects to iron out. Earth's cloud cover has been the greatest obstacle. As time goes on, cloud-piercing should be perfected. An ultimate challenge to scientists will be compensating for color differences in farm crops caused by overcast days.

Satellites of the late 1970's, in addition to infrared sensing, will probably plunge further into the invisible —getting into ultraviolet and microwave regions of the spectrum, revealing farm secrets we have not yet dreamed of.

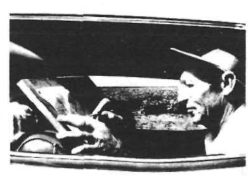
TEXAS

"I recall the first orbit the satellite made over my farm. It was a bright sunny day for pictures. There's no end to what satellites can do for farmers. My ground-truth observations and the satellite pictures together are run through a computer to establish shades of infrared color for crop troubles."
Albert Scheele, Floyd County farmer.

LOUISIANA

"Here in Louisiana, ASCS sometimes sends reporters out in boats to check fields. We have a lot of water. ERTS may point out water pollution caused by land breaking and leaving land bare in winter. This would increase no-tillage farming that is beginning to catch on in this area."
James Stewart, Madison Parish ASCS.

ARIZONA



"I believe outerspace infrared is the coming thing. When will this ERTS be a working reality? It depends on how fast the Government wants to push it and how much money the public wants to spend on the project. It has got to be a reality, I would say, inside 5 to 10 years."
Floyd Rose, Maricopa County ASCS.

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APPENDIX P

THE WASHINGTON POST *Wednesday, February 21, 1973*

Nations at U.N. Oppose U.S. Earth Data Offer

UNITED NATIONS — The United States has offered to disseminate data on natural resources obtained by its space satellites, but the offer — made at a meeting of a United Nations' space committee — has met opposition from several countries which don't want others to know what resources they have available.

Recently, the American delegate to the U.N. Working Group on Remote Sensing of the Earth by Satellites pledged that if an international data distribution center were established, the United States would provide it, with "a master copy" of all information obtained in the NASA Earth Resources program, which has been in experimental operation since July 1972.

The United States has already made detailed pictures from its first satellite, ERTS-1, available to all bidders at prices up to $10.

It is precisely this availability of data which has provoked the nervous reaction of several U.N. committee members.

By making use of the technology of military spy satellites, ERTS-1 is capable of sending back to earth data for almost all of the globe which is translatable into pictures. The information from this, and from more sophisticated satellites yet to come, will be useful for spotting wheat rust in a field; following fish and animal migrations; locating oil and metal deposits; monitoring air, ground and water pollution, and mapping erosion and water runoff.

The practical applications, according to experts from several nations who testified before the U.N. committee, are almost limitless.

NASA officials told the U.N. body that ERTS-1 was providing data to more than 100 foreign users, as well as American researchers. It has detected forest fires in Alaska, helped to plan the dredging of Tampa Bay, aided erosion control in Italy and corrected the maps of the Amazon Basin in Brazil.

In theory, if the space data is available to all, then everyone could benefit equally.

In practice, however, it is the nations with the technology to launch the satellites that command the technology to make effective use of the information obtained. As a result of the general availability of the space data, a middle-sized American mining corporation could know more about the mineral potential of an African or Latin American nation than that nation's scientists may know, unless it has contracted with the United States for data and interpretation from ERTS-1.

The poorer nations, who have no space experts, are largely unaware of any potential threat. It is the middle-sized nations—Mexico, Sweden, Austria, France and Canada—which have spoken out at the U.S. meetings.

A Canadian representative said the U.S. space committee (of which the satellite working group is an affiliate) should decide whether freedom of action in space is equated with "license to dispense information about your neighbor's affairs."

France called for restrictions on data relating to national resources.

Mexico maintained that the dissemination of data on a nation's resources, if done legally, would require prior authorization by each government, a principle the United States may have violated already.

One American representative, NASA executive Leonard Jaffe, responded to these grumblings by saying that space data on resources isn't much good without "correlative" information gained from ground and airplane observation, which governments are better able to control.

Arch Park, the chief of NASA's Earth Resources Survey Program, told the committee that the United States and the Soviet Union are pursuing "the same research pattern" in this field, and that the two powers "are now defining a series of joint experiments."

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APPENDIX Q

VOLCANOES AND BIOLOGICAL SYSTEMS

Excerpt from: Presentation by Dr. Kenneth Watt, University of California, at the Conference on the Environment and the Developing Professional, Institute for the Study of Health and Society, at Airlie House, Warrenton, Virginia, Oct. 23-26, 1969, Proceedings, pp. 33-56.

There is a very simple way of finding out the exact effect that volcanic eruptions have had on weather and on all biological systems. That is to try and relate the sun-spot cycle and the concentration of fine particles in the upper atmosphere as emitted from volcanic eruptions each to changes from year to year in the global mean temperature and see which one seems to be the causative agent. It turns out that the effect of the concentration of fine particles in the upper atmosphere over-rides changes in the sun-spot number. In other words, the major factor operating on global weather is not changes in the rate of emission of energy from the sun, but rather changes in the extent to which that emission can penetrate the albedo around the planet – the reflective shell of fine particles in the upper atmosphere. As that reflective shell becomes more dense, the penetration by the incident solar radiation can go down to 80% of what it might otherwise have been. The consequence is that there have been really cool periods in the last few centuries because of volcanic eruptions. It is of interest to consider just how large scale these effects have been.

This can be illustrated on a graph of three of the longest runs of data for any biological time series in the world. The top one is the catch of lynx – that is the number of lynx hides taken by the McKenzie District of the Hudson Bay Fur Company, and that variable goes back to 1735. It is only plotted from 1860 on to 1940. The second one is the incidence of influenza deaths per hundred-thousand people in England and Wales from 1860 to 1950. The third is a very long run of measurements of German forest insect pests, from 1880 to 1940 (Fig. J-1).

Looking at these variables carefully, this will give you an idea of the possible pervasive effects of air pollution in the future. You notice at first glance that these three graphs look very different. The top one looks very regular with respect to the zenith, the amplitude and the wave length, and it looks as if it is uninfluenced by any outside factor. That is the lynx graph.

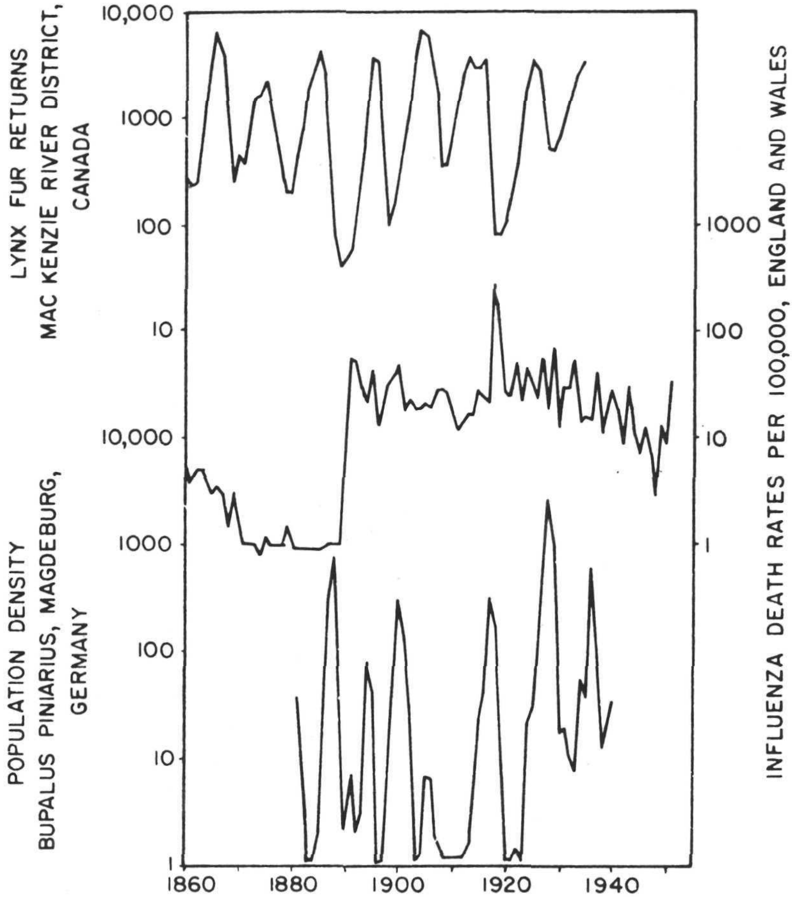

Figure J-1

The influenza graph, like the graphs for most epidemics on semi-log graph paper, shows a long period of quiesence followed by explosive outbreak and fluctuations that appear random about a slowly dropping mean. Plague, or any of the other great historical infectious diseases, has this character.

The temporal trend in German forest insect pest abundance is typical of biological time series which have a very irregular character. You notice an apparently very erratic nature in the wave lengths – the amplitude, zenith, nadir and everything else.

Let us go back and take another look. You notice on close inspection there are two very low nadirs in the lynx curve. Interestingly enough, these correspond to the two very sharp increases in incidence of influenza. These suggest that some sort

of global mechanism causes depressions in the lynx cycle and elevations in the influenza cycle. This is interesting because it turns out that this first great drop and this great rise came six years after Krakatoa, and this second great drop and this great rise came six years after Katmai. Those were the two great volcanic eruptions in this period.

Furthermore, it turns out that you can postulate specific biological mechanisms which will account for the six year lag. That is, for instance, if an adult female rabbit is starved in the winter time, this does not reflect itself in the number of young she has as much as the probability of survival of her young through the twelve-month period following the time when they were born. That will have an effect on the adult female lynx that eats them, and the same kind of effect on her young. Similarly, antibody-antigen type mechanisms – with mechanisms of seeding and dissemination – can account for the influenza lag following volcanic eruptions. So it would appear, first of all, that these two mechanisms are under some sort of common global mechanism. They also seem to have something to do with volcanic eruptions.

We know that insect population responds much more rapidly to changes, and if you study those cycles carefully, it turns out that they were fairly regular with respect to the wave length until you get here (diagram); the wave is simply missing. That came at the time of Katmai, the eruption of the volcano in Alaska. You notice we got a low nadir here just after the eruption of Krakatoa.

I should point out immediately that all of this I am trying to point out to you on an intuitive basis can be backed up by statistical analysis – some of it very sophisticated. For example, if you run this series back the whole length of the series, treat it as an auto-correlated time series, and then analyze the statistical behavior of residuals, it turns out that the big negative residuals all cluster six years after the major volcanic eruptions. In other words, the concentration of fine particles in the upper atmosphere is one of the pacemaker variables for all systems on the planet. The meteorologists in the last few years have been showing us that there is a tremendous increase globally occurring in concentration of fine particles in the upper atmosphere, coupled with the chilling of the planet; this shows what that will do.

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APPENDIX R

PROSPECTING IN ALABAMA

Excerpt from article in Aviation Week and Space Technology of September 18, 1972 entitled, "Apollo 9 Photo Finds New Features in Alabama," p. 40.

An end-of-the dav discussion of an Apollo 9 multispectral photograph of Alabama led to the discovery of a previously unknown set of lineaments crossing the Appalachian Mountains that may have economic as well as geological importance. According to James A. Drahovzal and Thornton L. Neathery of the Geological Survey of Alabama:

- Major lineaments appear to have a direct relationship with high yield springs and wells in Alabama and hence of hydrologic significance.
- Striking correlations are found between lineaments and hydrothermal mineral deposits in Alabama.

The Apollo 9 photograph had been sent to the U. S. Geological Survey regional office in Alabama by the National Aeronautics and Space Administration. It was being shown to the state geologists at a casual gathering, without any real study effort in mind. In trying to identify known geological features, the geologists bumped into the lineament pattern.

"Lineament" as a term has a general, non-commital meaning. It is any topographical line on the Earth's surface, and its cause is a matter of interpretation. In this case, Drahovzal and Neathery believe they are large fractures that are acting as avenues for distribution of ground water.

These fractures would also act as channels for mineralized fluids depositing gold, sulfide ores, barite or fluorite. "Some of the richest and most numerous barite deposits of the state occur at lineament junctions," Drahovzal said.

Lineaments also have seismic implications. Six of the 15 earthquakes recorded in Alabama since 1886 have occurred directly on two of the most geologically significant lineaments. This means that the lineament-causing features are still active, the Alabama geologists said, and are related to deep-seated structure.

These lineaments generally trend perpendicular to the axis of the Appalachians. Apollo 9 photography was limited to the Southern states because of orbital parameters, but Drahovzal and Neathery predict that more of these will be found in Earth Resources Technology Satellite imagery. Its polar orbit (AW&ST July 31, p. 46) permits global coverage.

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APPENDIX S

MEDICATION MANUFACTURING IN SPACE

Manufacturing in space is seen as a distinct possibility by cost-conscious teams from industry and the medical field. The following article is one example.

THE WASHINGTON POST Saturday, July 1, 1972 A3

Scientists Eye Space Production Of Costly Anti-Clotting Enzyme

By Thomas O'Toole
Washington Post Staff Writer

A team of industry-university scientists believes it is possible to make a rare and costly enzyme that dissolves blood clots by producing it in the weightless conditions of outer space.

So convinced is the research team of the worth of making this enzyme in space that the team is about to submit a proposal to the space agency that the enzyme be produced aboard the Apollo spacecraft that will be flown in earth orbit in 1975 for the joint American-Russian docking mission.

The enzyme is named urokinase and has been successfully used in the last four years by the National Heart and Lung Institute to treat 236 victims of pulmonary embolisms, clots that block the flow of blood to the lungs. The body produces urokinase, but not enough to dissolve clots that cause embolisms.

The Heart and Lung Institute paid $500,000 for the urokinase it has used in treating embolisms, a price of more than $1,000 per patient. The urokinase was extracted from human male urine by an unweildy process that produces only one dose of the enzyme from 1,500 quarts of urine.

A new method of making urokinase is what prompted the industry-university team to propose production of the enzyme in space. The team consists of scientists from Chicago's Abbott Laboritories, San Diego's Convair division of General Dynamics Corp. and the UCLA school of medicine.

The new method involves making the enzyme from the kidney cells of miscarried fetuses, which produce 50 times more urokinase than urine does. Kidney cells also turn out to be more manageable. A quart bottle of tiny but abundant kidney cells would be the equivalent of 50,000 quart bottles or urine.

A problem with kidney cells is that only one in 20 can be made to produce urokinase, which is where the Abbott-Convair-UCLA team came together to suggest that the enzyme be made in space. At the heart of their suggestion is the development by UCLA biophysicist Alexander Kolin of a machine that separates the one "active" kidney cell from the 19 inactive cells that don't make urokinase.

Kolin's device separates the cells by electrophoresis, using a moving electrical field to carry cells of different densities along at different rates of speed. Kolin has already shown that he can isolate the active kidney cells on earth, a procedure he and his colleagues believe can better be done in space where there is no gravity working against separation.

"Urokinase is a lifesaving drug that's unavailable to man because of its price," says Abbott Laboratories' Grant Barlow. "What we have here is a method of producing this drug at a price that man can afford."

Barlow points out that the kidney cells would be separated aboard a spacecraft, then ampuled, frozen and brought back to earth where urokinase would be produced from the active cells in a pharmaceutical plant.

"Even allowing for this we could reduce the price by a factor of 20," Barlow said. "Our calculations show a price of $50 per dose for urokinase if we could use this method in space."

The Abbott-Convair-UCLA team has yet to propose their scheme to the space agency, but NASA officials say they have heard of it.

"It sounds like a bright and hopeful development," said the space agency's Dr. James Bredt, "but that's all we can say about it at this time."

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APPENDIX T

VOICES FROM 370 B. C.

Socrates: *Shall we make astronomy the next study? What do you say?*

Glaucon: *Certainly. A working knowledge of the seasons, months and years is beneficial to everyone, to commanders as well as to farmers and sailors.*

Socrates: *You make me smile, Glaucon. You are so afraid that the people will think you to be recommending unprofitable studies.*

I admit it is difficult to convince the multitude, but in every man's soul there is an organ which is purified and kindled afresh by such studies. This faculty is destroyed and blinded by ordinary pursuits. This eye of the soul outweighs ten thousand bodily eyes, for by it alone is truth seen.

Plato, Republic VII
Circa 370 B.C.

APPENDIX U

THE NUN AND THE SCIENTIST

Some of the reasons for exploring space, when there are numerous social problems on earth, were described recently by Dr. Ernst Stuhlinger, Associate Director of Science at the Marshall Space Flight Center, Huntsville.

His beliefs were expressed in his reply to a letter from Sister Mary Jucunda, O.P., a nun who works among starving natives of Zambia, Africa.

Your letter was one of many which are reaching me every day, but it has touched me more deeply than all the others because it came so much from the depth of a searching mind and a compassionate heart.

I will try to answer your question as best as I possibly can.

First, however, I would like to say what great admiration I have for you, and for all your many brave sisters, because you are dedicating your lives to the noblest cause of man: help for his fellow men who are in need.

You asked in your letter how I can suggest the expenditures of billions of dollars for a voyage to Mars, at a time when many children on this earth are starving to death.

I know that you do not expect an answer such as "Oh, I did not know that there are children dying from hunger, but from now on I will desist from any kind of space research until mankind has solved that problem!"

In fact, I have known of famined children long before I knew that a voyage to the planet Mars is technically feasible.

However, I believe, like many of my friends, that traveling to the moon and eventually to Mars and to other planets is a venture which we should undertake now. I even believe that this project, in the long run, will contribute more to the solution of these grave problems we are facing here on earth than many other potential projects of help which are debated and discussed year after year, and which are so extremely slow in yielding tangible results.

Before trying to describe in more detail how our space program is contributing to the solution of our earthly problems, I would like to relate briefly a true story which may help support the argument.

About 400 years ago, there lived a count in a small town in Germany. He was one of the benign counts and he gave a large part of his income to the poor in his town. This was much

appreciated because poverty was abundant during medieval times and there were epidemics of the plague which ravaged the country frequently.

One day, the count met a strange man. He had a workbench and little laboratory in his house, and he labored hard during the daytime so that he could afford a few hours every evening to work in his laboratory.

He ground small lenses from pieces of glass; he mounted the lenses in tubes and he used these gadgets to look at very small objects. The count was particularly fascinated by the tiny creatures that could be observed with the strong magnification and which nobody had ever seen before.

He invited the man to move with his laboratory to the castle, to become a member of the count's household and to devote henceforth all his time to the development and perfection of his optical gadgets as a special employee of the count.

The townspeople, however, became angry when they realized that the count was wasting his money, as they thought, on a stunt without purpose. "We are suffering from this plague," they said, "while he is paying that man for a useless hobby!"

But the count remained firm. "I give you as much as I can afford," he said, but I will also support this man and his work, because I know that someday something will come out of it."

Indeed, something very good came out of this work, and also out of similar work done by others at other places: the microscope. It is well known that the microscope has contributed more than any other invention to the progress of medicine and that the elimination of the plague and many other contagious diseases from most parts of the world is largely a result of studies which the microscope made possible.

The count, by retaining some of his spending money for research and discovery, contributed far more to the relief of human suffering than he could have contributed by giving all he could possibly spare to his plague-ridden community.

The situation which we are facing today is similar in many respects. The President of the United States is spending about $200 billion in his yearly budget. This money goes to health, education, welfare, urban renewal, highways, transportation, foreign aid, defense, conservation, science, agriculture and many installations inside and outside the country.

About 1.6 per cent of this national budget was allocated to space exploration this year. The space program includes Project Apollo, and many other smaller projects in space physics, space astronomy, space biology, planetary projects, earth resources projects and space engineering.

To make this expenditure for the space program possible, the average American taxpaper with $10,000 income per year is paying about $30 for space.

The rest of his income, $9,970, remains for his subsistence, his recreation, his savings, his taxes and all his other expenditures.

You will probably ask now: "Why don't you take 5 or 3 or 1 dollar out of the 30 space dollars which the average American taxpaper is paying and send these dollars to the hungry children?"

To answer this question, I have to explain briefly how the economy of this country works. The situation is very similar in other countries.

The government consists of a number of departments (Interior; Justice; Health; Education; Welfare; Transportation; Defense; and others), and of bureaus (National Science Foundation; National Aeronautics and Space Administration and others).

All of them prepare their yearly budgets according to their assigned missions and each of them must defend its budget against extremely severe screening by congressional committees and against heavy pressure for economy from the Bureau of the Budget and the President. When the funds are finally appropriated by Congress, they can be spent only for the line items specified and approved in the budget.

The budget of the National Aeronautics and Space Administration, naturally, can contain only items directly related to aeronautics and space. If this budget were not approved by Congress, the funds proposed for it would not be available for something else. They would simply not be levied from the taxpaper, unless one of the other budgets had obtained approval for a specific increase which would then absorb the funds not spent for space.

You may realize from this brief discourse that support for hungry children, or rather a support in addition to what the United States is already contributing to this very worthy cause in the form of foreign aid, can be obtained only if the appropriate department submits a budget line item for this purpose and if this line item is then approved by Congress.

You may ask now whether I personally would be in favor of such a move by our government. My answer is an emphatic yes. Indeed, I would not mind it at all if my annual taxes were increased by a number of dollars for the purpose of feeding hungry children wherever they may live. I know that all of my friends feel the same way.

However, we could not bring such a program to life merely by desisting from making plans for voyages to Mars. On the contrary, I even believe that by working for the space program I

can make some contribution to the relief and eventual solution of such grave problems as poverty and hunger on earth.

Basic to the hunger problem are two functions: the production of food and the distribution of food. Food production by agriculture, cattle ranching, ocean fishing and other large scale operations is efficient in some parts of the world, but drastically deficient in many others.

For example, large areas of land could be utilized far better if efficient methods of watershed control, fertilizer use, weather forecasting, fertility assessment, plantation programming, field selection, planting habits, timing of cultivation, crop survey and harvest planning were applied.

The best tool for the improvement of all these functions, undoubtedly, is the artificial earth satellite. Circling the globe at a high altitude, it can screen wide areas of land within a short time, it can observe and measure a large variety of factors indicating the status and conditions of crops, soil, droughts, rainfall, snow cover, etc., and it can radio this information to ground stations for appropriate use.

It has been estimated that even a modest system of earth satellites equipped with earth resources sensors, working within a program for worldwide agricultural improvement, will increase the yearly crops by an equivalent of many billions of dollars.

The distribution of the food to the needy is a completely different problem. The question is not so much one of shipping volume, it is one of international cooperation.

The ruler of a small nation may feel very uneasy about the prospects of having large quantities of food shipped into his country by a large nation, simply because he fears that along with the food there may also be an import of influence and foreign power.

Efficient relief from hunger, I am afraid, will not come before the boundaries between nations have become less dividing than they are today.

I do not believe that space flight will accomplish this miracle overnight. However, the space program is certainly among the most promising and powerful agents working in this direction.

Let me only remind you of the recent near-tragedy of Apollo 13. When the time of the crucial reentry of the astronauts approached, the Soviet Union discontinued all Russian radio transmissions in the frequency bands used by the Apollo Project in order to avoid any possible interference, and the Russian ships stationed themselves in the Pacific and the Atlantic oceans in case an emergency rescue would become necessary.

Had the astronauts' capsule touched down near a Russian ship, the Russians would undoubtedly have expended as much care and effort in their rescue as if Russian cosmonauts had returned from a space trip.

If Russian space travelers should ever be in a similar emergency situation, Americans would do the same without any doubt.

Higher food production through survey and assessment from orbit, and better food distribution through improved international relations, are only two examples of how profoundly the space program will impact life on earth.

I would like to quote two other examples: stimulation of technological development and generation of scientific knowledge.

The requirements for high precision and for extreme reliability which must be imposed upon the components of a moon-traveling spacecraft are entirely unprecedented in the history of engineering.

The development of systems which meet these severe requirements has provided us a unique opportunity to find new materials and methods, to invent better technical systems, to improve manufacturing procedures, to lengthen the lifetimes of instruments and even to discover new laws of nature.

All this newly acquired technical knowledge is also available for applications to earthbound technologies. Every year, about a thousand technical innovations generated in the space program find their ways into our earthly technology where they lead to better kitchen appliances and farm equipment, better sewing machines and radios, better ships and airplanes, better weather forecasting and storm warning, better communications, better medical instruments, better utensils and tools for everyday life.

Presumably, you will ask now why we must develop first a life support system for our moon-traveling astronauts, before we can build a remote-reading sensor system for heart patients.

The answer is simply: significant progress in the solution of technical problems is frequently made not by a direct approach, but by first setting a goal of high challenge which offers a strong motivation for innovative work, which fires the imagination and spurs men to expend their best efforts, and which acts as a catalyst by including chains of other reactions.

Space flight, without any doubt, is playing exactly this role. The voyage to Mars will certainly not be a direct source of food for the hungry. However, it will lead to so many new technologies and capabilities that the spinoffs from this project alone will be worth many times the cost of its implementation.

Besides the need for new technologies, there is a continuing great need for new basic knowledge in the sciences if we wish to improve the conditions of human life on earth.

We need more knowledge in physics and chemistry, in biology and physiology, and very particularly in medicine to cope with all these problems which threaten man's life: hunger, disease, contamination of food and water, pollution of the environment.

We need more young men and women who choose science as a career, and we need better support for those scientists who have the talent and the determination to engage in fruitful research work.

Challenging research objectives must be available, and sufficient support for research projects must be provided. Again, the space program with its wonderful opportunities to engage in truly magnificent research studies of moon and planets, of physics and astronomy, of biology and medicine is almost the ideal catalyst which induces the reaction between the motivation for scientific work, opportunities to observe exciting phenomena of nature, and material support needed to carry out the research effort.

Among all the activities which are directed, controlled and funded by the American government, the space program is certainly the most visible, and probably the most debated activity, although it consumes only 1.6 per cent of the total national budget.

As a stimulant and catalyst for the development of new technologies, and for research in the basic sciences, it is unparalleled by any other activity. In this respect, we may even say that the space program is taking over a function which for three or four thousand years has been the sad prerogative of wars.

How much human suffering can be avoided if nations, instead of competing with their bomb-dropping fleets of airplanes and rockets, compete with their moon-traveling space ships! This competition is full of promise for brilliant victories, but it leaves no room for the bitter fate of the vanquished which breeds nothing but revenge and new wars.

Although our space program seems to lead us away from our earth and out toward the moon, the sun, the planets and the stars, I believe that none of these celestial objects will find as much attention and study by space scientists as our earth.

It will become a better earth, not only because of all the new technological and scientific knowledge which we will apply to the betterment of life, but also because we are developing a far deeper appreciation of our earth, of life, and of man.

The photograph which I enclose with this letter shows a view of our earth as seen from Apollo 8 when it orbited the moon at Christmas, 1968.

Of all the many wonderful results of the space program so far, this picture may be the most important one.

It opened our eyes to the fact that our earth is a beautiful and most precious island in an unlimited void, and that there is no other place for us to live but the thin surface layer of our planet, bordered by the bleak nothingness of space.

Never before did so many people recognize how limited our earth really is, and how perilous it would be to tamper with its ecological balance.

Ever since this picture was first published, voices have become louder and louder warning of the grave problems that confront man in our times: pollution, hunger, poverty, urban living, food production, water control, overpopulation.

It is certainly not by coincidence that we begin to see the tremendous tasks waiting for us at a time when the young space age has provided us the first good look at our own planet.

Very fortunately, though, the space age not only holds out a mirror in which we can see ourselves, it also provides us with the technologies, the knowledge, the challenge, the motivation, and even with the optimism to attack these tasks with confidence.

What we learn in our space program, I believe, is fully supporting what Albert Schweitzer had in mind when he said:

"I am looking at the future with concern, but with good hope."

My very best wishes will always be with you – Ernst Stuhlinger.

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